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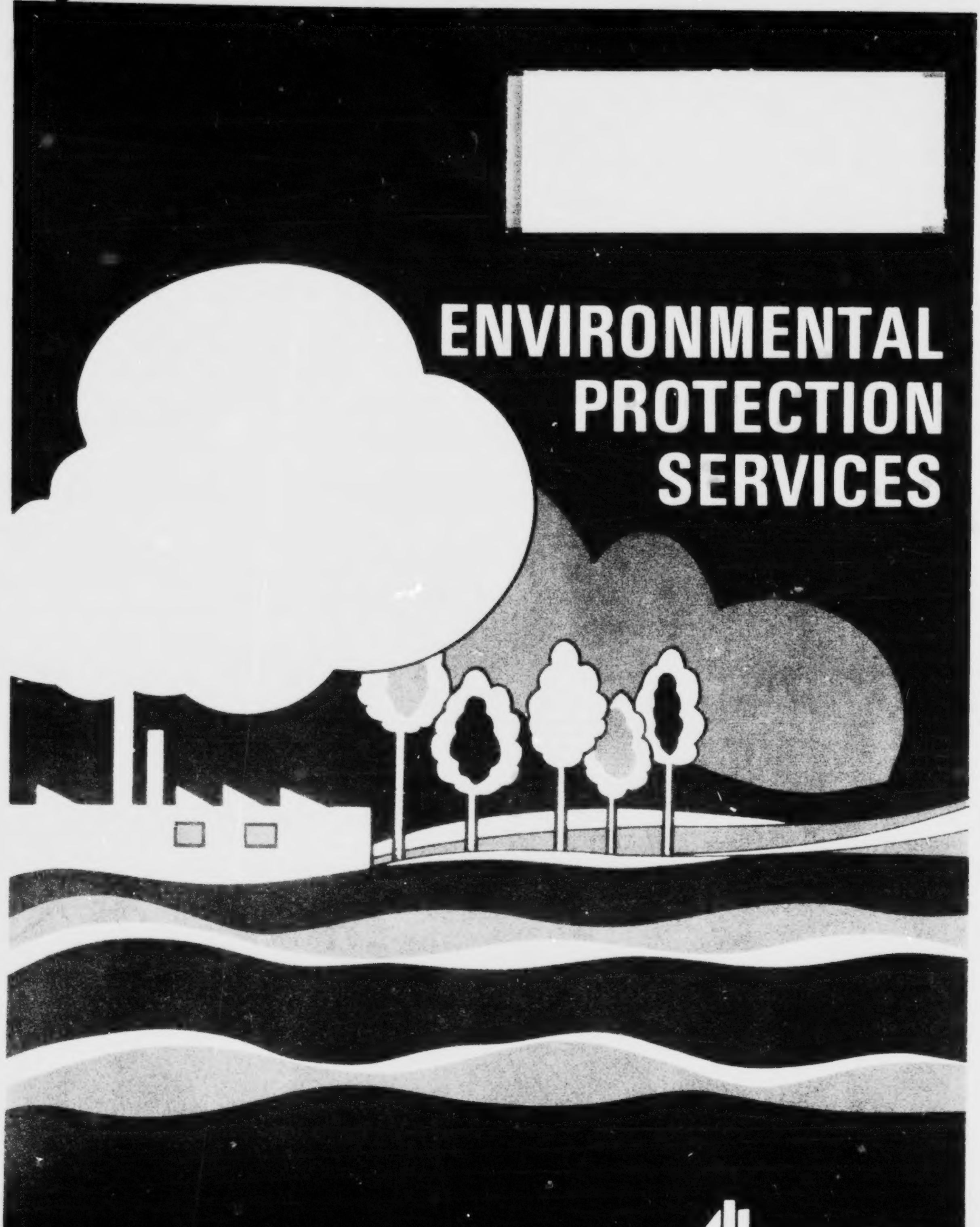

ENVIRONMENTAL PROTECTION SERVICES

Alberta
ENVIRONMENT

RESULTS OF INVESTIGATIONS
AT PRIORITY 1 LANDFILL
SITES IN ALBERTA

ALBERTA ENVIRONMENT
ENVIRONMENTAL PROTECTION SERVICES
EARTH SCIENCES DIVISION
GROUNDWATER PROTECTION BRANCH

Prepared by:	Submitted by:
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January, 1986

#472

ABSTRACT

Alberta Environment initiated a study in 1981 to investigate waste disposal sites in the Province. In phase I and II of the study an inventory of all active and abandoned land disposal sites was compiled. An attempt was made to rate each site according to its threat to public health and/or the environment. Of 1152 active and inactive disposal sites identified, eighteen were assessed as potentially threatening. In phase III, detailed hydrogeological investigations were conducted by Alberta Environment at seventeen of the eighteen sites. At twelve of the sites only minimal groundwater contamination was found and remedial action or further monitoring will not be necessary. Five of the sites were found to require additional monitoring to further assess suspected groundwater contamination and/or investigate anomalous data. One site will be investigated in January or February, 1986, since winter conditions are required to obtain access.

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1. INTRODUCTION

In 1981, Alberta Environment, initiated a study to identify all waste disposal sites in the Province and to assess their impact on public health and the environment. A phased approach was adopted to facilitate the review of study progress.

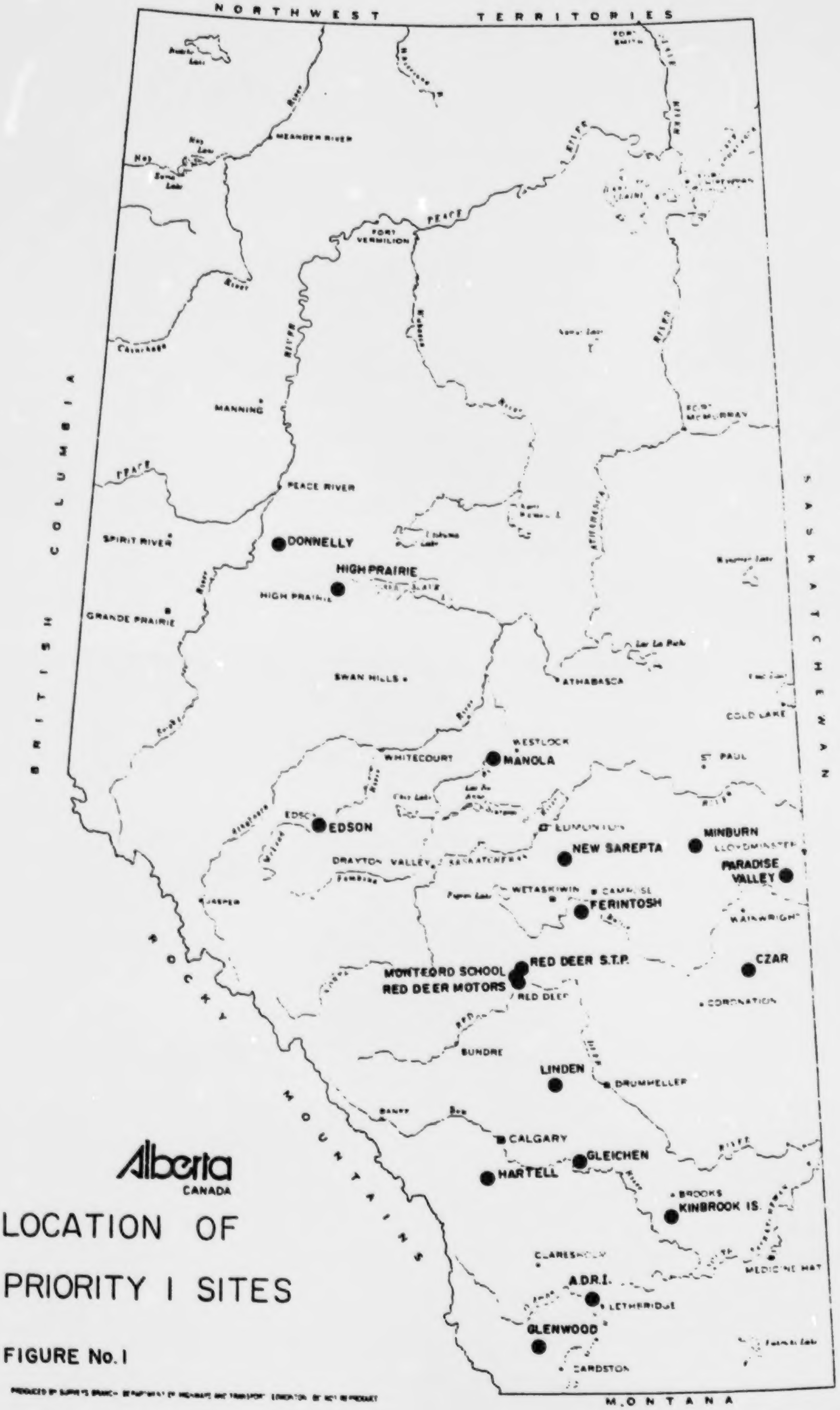
The first phase involved compiling an inventory of all waste disposal facilities and developing a ranking system in order to rate the sites according to their impact on the environment. A total of 1152 active and abandoned waste sites were identified (MacLaren Plansearch Lavalin, 1982). Of these sites, 167 were designated Class 1, or sites requiring further investigation.

The second phase of the study, initiated in 1983, reviewed the 167 Class 1 sites and qualitatively assessed their impact on the environment (Associated Engineering Services Ltd., 1985). Assessments involved a literature review, interviews with local officials and a visit to each site. Of the 167 Class 1 sites, 18 were judged to be Priority 1, or sites requiring immediate attention because they were considered to present an immediate or potential threat to public health or the environment. The sites are located predominantly in central and southern Alberta (Figure 1).

2. PHASE III - DETAILED STUDIES

Phase III of the study, completed by Alberta Environment, involved a detailed hydrogeological investigation at seventeen of the eighteen sites. Local officials involved with the sites were advised of additional work being planned and access arrangements were made with their assistance.

Work planned for each of the eighteen sites included a terrain conductivity survey, test drilling, monitoring well installation, estimation of in-situ hydraulic conductivity, and groundwater sampling


NORTHWEST TERRITORIES
BRITISH COLUMBIA
SASKATCHEWAN
MONTANA
ROCKY MOUNTAINS
FORT SMITH
MEANDER RIVER
FORT VERMILION
PEACE
MANNING
PEACE RIVER
SPIRIT RIVER
GRANDE PRAIRIE
FORT McMURRAY
DONNELLY
HIGH PRAIRIE
HIGH PRAIRIE
SWAN HILLS
ATHABASCA
COLD LAKE
WESTLOCK
WHITECOURT
MANOLA
ST. PAUL
EDSON
EDSON
EDMONTON
MINBURN
LLOYDMINSTER
NEW SAREPTA
PARADISE VALLEY
DRAYTON VALLEY
SASKATCHEWAN
JASPER
WETASKIWIN
CAMROSE
FERINTOSH
WAINWRIGHT
RED DEER S.T.P.
MONTEORD SCHOOL
RED DEER MOTORS
RED DEER
CZAR
CORONATION
SUNDRE
LINDEN
DRUMHELLER
BANFF
CALGARY
GLEICHEN
HARTELL
BROOKS
KINBROOK IS.
CLARESHOLM
MEDICINE HAT
A.D.R.I.
LETHBRIDGE
GLENWOOD
CARDSTON
Alberta
CANADA

LOCATION OF PRIORITY I SITES

FIGURE No. I

for chemical analysis. Details of field investigation techniques are contained in Appendix A. Data derived from the field activities were used to obtain information about geology, hydrogeology, groundwater chemistry, and the level and extent of groundwater contamination. The level of groundwater contamination at each site was assessed by comparing the chemistry of groundwater down-gradient from a disposal facility to that of up-gradient groundwater. The threat of contaminated water to public health was determined by comparison to Canadian Drinking Water Standards (Health and Welfare Canada, 1978).

Reports containing results of detailed investigations at seventeen sites are found in Appendix B. An investigation was not conducted at the Kinbrook Island disposal area because the site, located on an island in Lake Newell, was inundated. An attempt will be made to conduct test drilling in January or February, 1986 (providing there is sufficient ice thickness).

3. SUMMARY AND CONCLUSIONS

Extensive groundwater or surface water contamination (i.e., posing a significant risk to public health) was not detected at any of the sites investigated. To express the level of contamination the following rating was used:

CLASS 1. Sites for which groundwater contamination has been detected. Groundwater down-gradient from the disposal facility is poorer quality than background water, with the concentration of several constituents exceeding recommended upper limits for Canadian Drinking Water. Additional monitoring is required to determine the level, extent and impact of contamination.

CLASS 2. Sites for which groundwater contamination is suspected. Additional monitoring is required to confirm anomalous data or to obtain additional information.

CLASS 3. Insignificant or no groundwater contamination detected. Groundwater down-gradient from the disposal facility is chemically similar to background water. No further action required.

A rating of each site is contained in Table 1. Of seventeen sites investigated, twelve are Class 3, three are Class 2 and two are Class 1.

TABLE 1. SUMMARY OF DETAILED INVESTIGATIONS

LANDFILL	CLASS	RECOMMENDATIONS
1. Animal Diseases Research Institute (NE 12-09-23-W4)	3	No action required
2. Czar (SE 20-40-06-W4)	3	No action required
3. Donnelly (SE 12-78-21-W5)	3	No action required
4. Edson (NE 09-53-17-W5)	2	Additional drilling required south of disposal site in muskeg area
5. Ferintosh (NW 03-44-21-W4)	3	No action required
6. Gleichen (SW 24-22-23-W4)	3	No action required
7. Glenwood (SW 01-05-27-W4)	2	Additional groundwater sampling required
8. Hartell (NE 09-19-02-W5)	3	No action required
9. High Prairie (SE 26-74-17-W5)	1	Collect samples from West Prarie River and resample W364
10. Kinbrook Island (NE 19-17-14-W4)	N/A	Drilling program to be conducted in early 1986
11. Linden (SE 20-30-25-W4)	3	No action required
12. Manola (NE 16-59-2-W5)	3	No action required
13. Minburn (SW 14-50-10-W4)	2	Resample P309 to confirm anomalously high organic load
14. New Sarepta (NW 34-49-22-W4)	3	No action required
15. Paradise Valley (NW 7-47-2-W4)	3	No action required
16. Red Deer (Montfort School) (NE 20-38-27-W4)	3	No action required
17. Red Deer Motors (SE 8-38-27-W4)	3	No action required
18. Red Deer (Sewage Treatment Plant) (NW 34-38-27-W4)	1	Collect additional samples of the river for chemical analysis. Obtain accurate hydraulic conductivity data for geologic materials between the landfill and the river.

4. REFERENCES

Associated Engineering Services Ltd., 1985: Field Investigation of Waste Disposal Sites. Report prepared for Alberta Environment.

Health and Welfare Canada, 1978: Guidelines for Canadian Drinking Water Quality 1978.

MacLaren Plansearch Lavalin, 1982: Identification and verification of active and inactive land disposal sites in Alberta. Report prepared for Alberta Environment and Environment Canada.

APPENDIX A

DETAILS OF FIELD INVESTIGATION TECHNIQUES

Electromagnetic Survey

An electromagnetic (EM) survey was conducted at nine sites using a Geonics EM-31 instrument. The remainder of the sites were not suitable for an EM survey because of extreme topographic relief, which may effect conductivity measurements, or access problems. The purpose of the survey was to define the limits of the disposal area, to provide a qualitative assessment of the areal extent of groundwater contamination and to site monitoring wells. The instrument used consists of a transmitter and receiver coil separated by a 3.6 m frame. An alternating current produced in the transmitter coil generates a magnetic field which penetrates the ground surface and induces current flow through earth materials in proportion to their electrical conductivities. The induced currents generate a secondary magnetic field which is picked up by the receiver coil. For the EM-31 the approximate depth of penetration with the coils in the horizontal and vertical position is approximately 6 m and 3 m, respectively.

Several transects were completed for each survey. The distance between measurement points varied from a 10 m grid for small areas to a 20 m grid for the larger sites. Areas of high conductivity generally indicate areas underlain by refuse or leachate-contaminated water.

Test Drilling

All boreholes were augered using a B-61 rig equipped with 11.5 cm O.D. solid stem auger. Fluids were not used during drilling to minimize contamination of groundwater. Drill cuttings were collected at 0.5 m intervals and detailed descriptions recorded. Descriptions include information about lithology, structure and moisture content.

Monitoring Well (Monitor) Completion

Water table wells and piezometers were employed in the study. Construction details are schematically represented in Figure A1. Water level information from water table wells was used to obtain information about the water table. Where possible a water table contour map was

0
10
20
30
40
50

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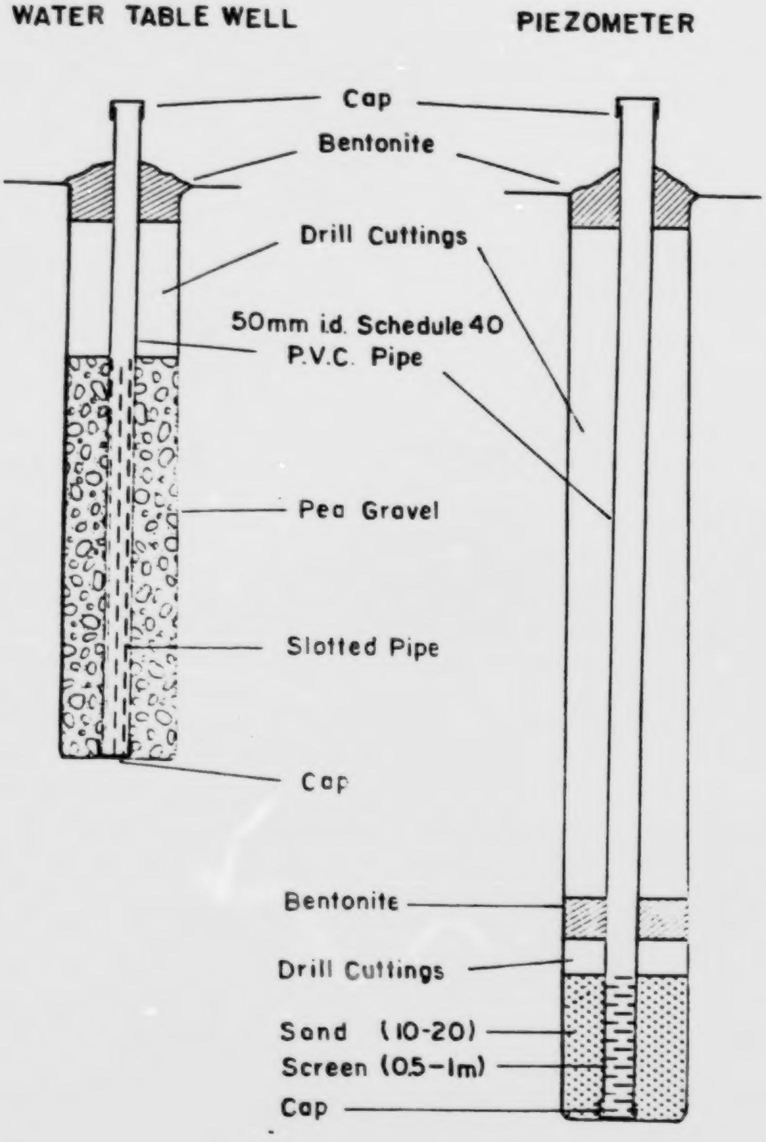

WATER TABLE WELL
PIEZOMETER
Cap
Bentonite
Drill Cuttings
50mm i.d. Schedule 40
P.V.C. Pipe
Pea Gravel
Slotted Pipe
Cap
Bentonite
Drill Cuttings
Sand (10-20)
Screen (0.5-1m)
Cap

DRAWING No

FILE No

Alberta ENVIRONMENT

SUBMITTED
DATE
APPROVED
DATE
DESIGNED
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DRAWN
CHECKED

MONITOR COMPLETION

SCALE
DATE
SHEET OF
FIGURE No. A1

constructed to determine the direction of shallow groundwater flow. Water level data from water table well/piezometer nests were used to establish the vertical component of groundwater flow. For example, in groundwater recharge areas, the hydraulic head decreases with depth.

Groundwater Sampling

Groundwater from piezometers and water table wells were sampled on at least one occasion for hydrochemical analysis. Care was taken to minimize the effects of CO_2 degassing and O_2 ingassing to ensure the samples collected were representative of groundwaters sampled. Samples were collected using a peristaltic pump and were filtered in the field using a 0.45 um membrane filter. The filter unit was cleaned with distilled water and a new filter membrane was used for each sample. Where practicable at least one bore-hole volume of water was removed before sample collection to ensure the sample was representative of formation water.

Four separate samples were collected at each sampling site. Each sample bottle was thoroughly rinsed with sample water before sample collection. Once collected, the samples were packed in an ice-filled cooler and sent to the laboratory as soon as possible. Analyses were made for major ions, metals, TOC and COD. A complete list of parameters analyzed and preservation techniques is presented in Table A1.

Additional groundwater samples were collected for detailed organic analysis from two wells at each of the Montford School, Red Deer (S.T.P.) and Red Deer Motors landfill sites. These extra samples were collected because initial testing indicated a high organic load in shallow groundwater at the sites. Each sample was analyzed using gas chromatography/mass spectrometry (GC/MS) to identify extractable priority pollutants.

GC/MS and total organic carbon (TOC) analysis were conducted at the Alberta Environmental Centre. All other parameters were analyzed by the Technical Development Branch of the Earth Sciences Division.

TABLE A1: SAMPLING PROCEDURES AND PRESERVATION TECHNIQUES

Chemical parameter	Method of Preservation
Inorganic	
Cl, SO_4, HCO_3, NH_4, NO_3	- 250 ml plastic bottle
Na, K, Ca, Mg	- refrigerate
Organic	
COD	- 125 ml plastic bottle - acidify 5 ml H_2SO_4 - refrigerate
TOC	- 125 ml plastic bottle - refrigerate
Metals	
Cu, Fe, Mn, Pn, Zn	- 125 ml plastic bottle - acidify 5 ml (1:1) HNO_3 - refrigerate

APPENDIX B

SITE REPORTS (IN ALPHABETICAL ORDER)

ANIMAL DISEASES RESEARCH INSTITUTE
(A.D.R.I.) LANDFILL
Pt. N.E. 12-9-23-W4

LOCATION AND SITE DESCRIPTION

- the site is located on the flood plain of the Oldman River (Figure 1);
- the site contains three disposal areas; one active and two reclaimed (Figure 2);
- disposal areas are approximately 1.2 ac (0.5 ha) in size;

FIELD PROGRAM

Test Drilling and Monitor Completion

- fourteen test holes were drilled (locations shown in Figure 2 and borehole logs attached);
- fourteen water table wells were installed (completion details in Table 1);

EM Survey

- twelve transects were completed using the EM-31 device in the vertical (approximately 3 m depth of penetration) and horizontal (approximately 6 m depth of penetration) modes (Figures 3 & 4);
- the spacing between measurement points was 15 m;
- the spacing between transects was 15 to 20 m;
- transects crossed over the three disposal areas and an area adjacent to the incinerator.

Monitoring

- water levels have been recorded five times since August 21, 1985;
- groundwater and river samples were collected for chemical analysis on October 2, 1985 (Table 3).

STUDY RESULTS

Geology

- in the vicinity of the disposal areas alluvial sand and gravel overlie shale bedrock (Figure 5);

- refuse pits have been excavated in the sand and gravel deposits to a depth of approximately 3 m;

Hydrogeology

- the direction of shallow groundwater flow is to the south-southwest, toward the Oldman River (Figure 6);
- the horizontal hydraulic gradient is very low, common in sand and gravel deposits;
- the depth to the water table varies from less than 3 m below ground in the southwest part of the study to greater than 9 m in the northeast;
- the shallow groundwater system is hydraulically connected to the river;
- the average hydraulic conductivity of the sand and gravel is 2×10^{-3} cm/s.
- based on visual grain size analysis the shallow bedrock has a low permeability.

EM Survey

- conductivity values are fairly uniform across the site at both the 3 and 6 m depths, indicating no anomalies in terrain conductivity;
- higher conductivity values in the topographic low areas are probably due to the shallower water table.

Groundwater Chemistry

- groundwater throughout the site is predominantly the calcium-magnesium/bicarbonate type with a total dissolved solids (TDS) concentration < 500 mg/L (Figure 7);
- exceptions to this occur in the background wells at 4467-T and 4469-T where TDS concentrations are 1890 and 937 mg/L, respectively;
- the groundwater at 4467-T is the sodium sulphate type;
- a slightly elevated COD concentration in groundwater from 4464-T and 4465-T may indicate some contamination by organics;
- no explanation is available for the high COD in groundwater from 4469-T, which is located up-gradient from the disposal areas.

Oldman River Water Chemistry

- water from the Oldman River adjacent to the A.D.R.I. landfills is the calcium-magnesium/bicarbonate type with a TDS concentration < 200 mg/L.

CONCLUSIONS

- the site is underlain predominantly by alluvial sand and gravel deposits;
- minimal groundwater contamination was detected down-gradient from the disposal areas;
- the more mineralized groundwater, taken from background wells (4467-T and 4469-T) located near the edge of the alluvial deposits adjacent to the Oldman River Valley coulee, has a chemical analysis typical to groundwater occurring in glacial till.

RECOMMENDATIONS

- although a groundwater contamination problem was not identified at this location it is recommended that future landfilling practices occur in a much less permeable material and in an area which would not be subjected to periodic flooding by the Oldman River;
- it is recommended that monitoring at the site be discontinued and that the site be down-graded to low priority.

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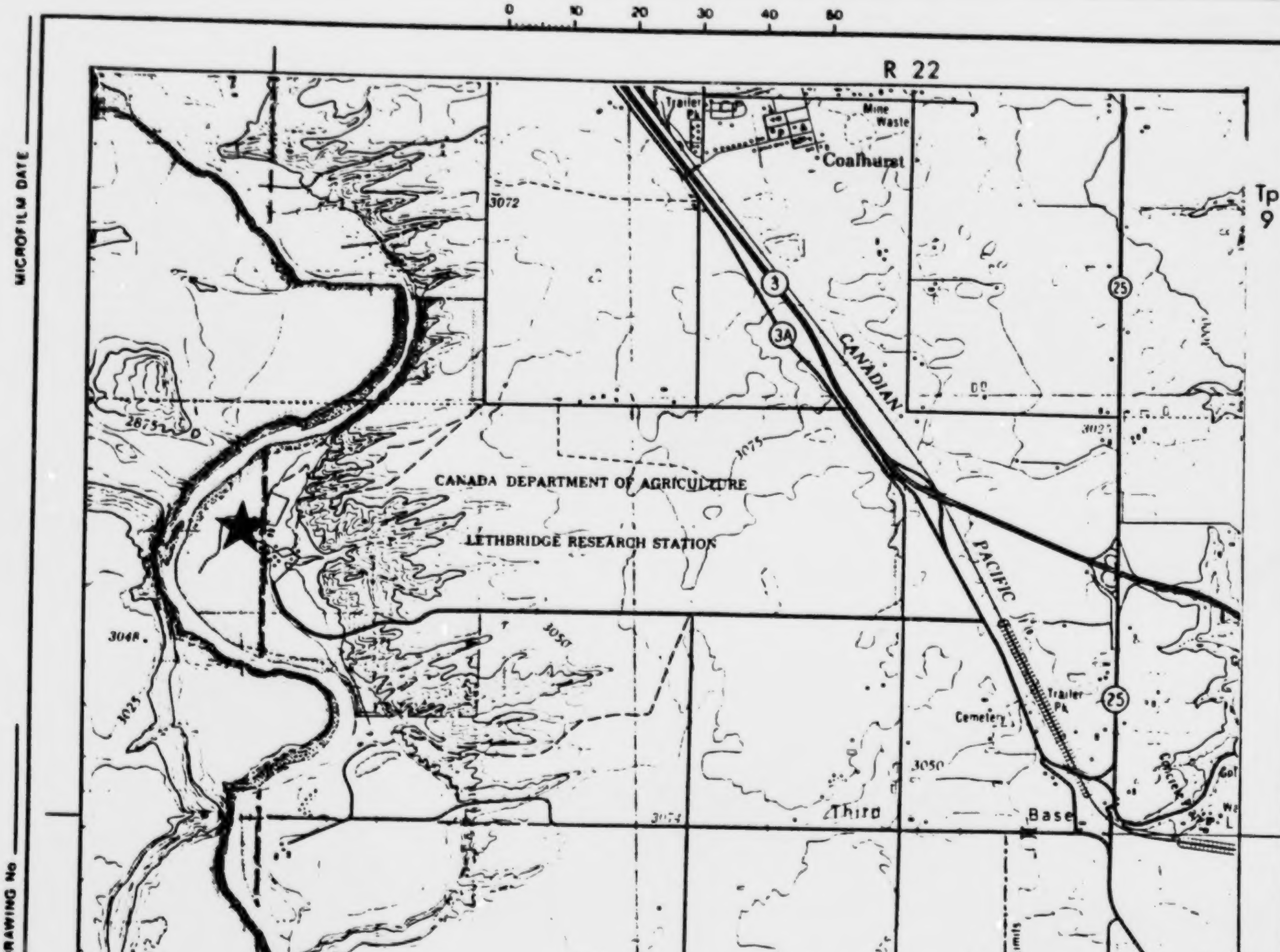

0
10
20
30
40
50
R 22
Trailer Pk
Mine Waste
Coalhurst
3072
Tp 9
3
3A
CANADIAN
25
PACIFIC
2875
3025
CANADA DEPARTMENT OF AGRICULTURE
LETHBRIDGE RESEARCH STATION
3048
3050
3075
Trailer Pk
Cemetery
3050
Third
Base
3074
City Limits
3077
CARDSTON
MUNICIPAL
DISTRICT
LETHBRIDGE
COUNTY
2780
3075
Tp 8
Edmonton
Calgary
ALBERTA
©A.D.R.I.

Alberta
ENVIRONMENT

SUBMITTED W. I. ......
DATE Feb. 14/86
APPROVED ......
DATE Feb. 14/86

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A.D.R.I. LANDFILL STUDY

LOCATION PLAN

SCALE 1:50000
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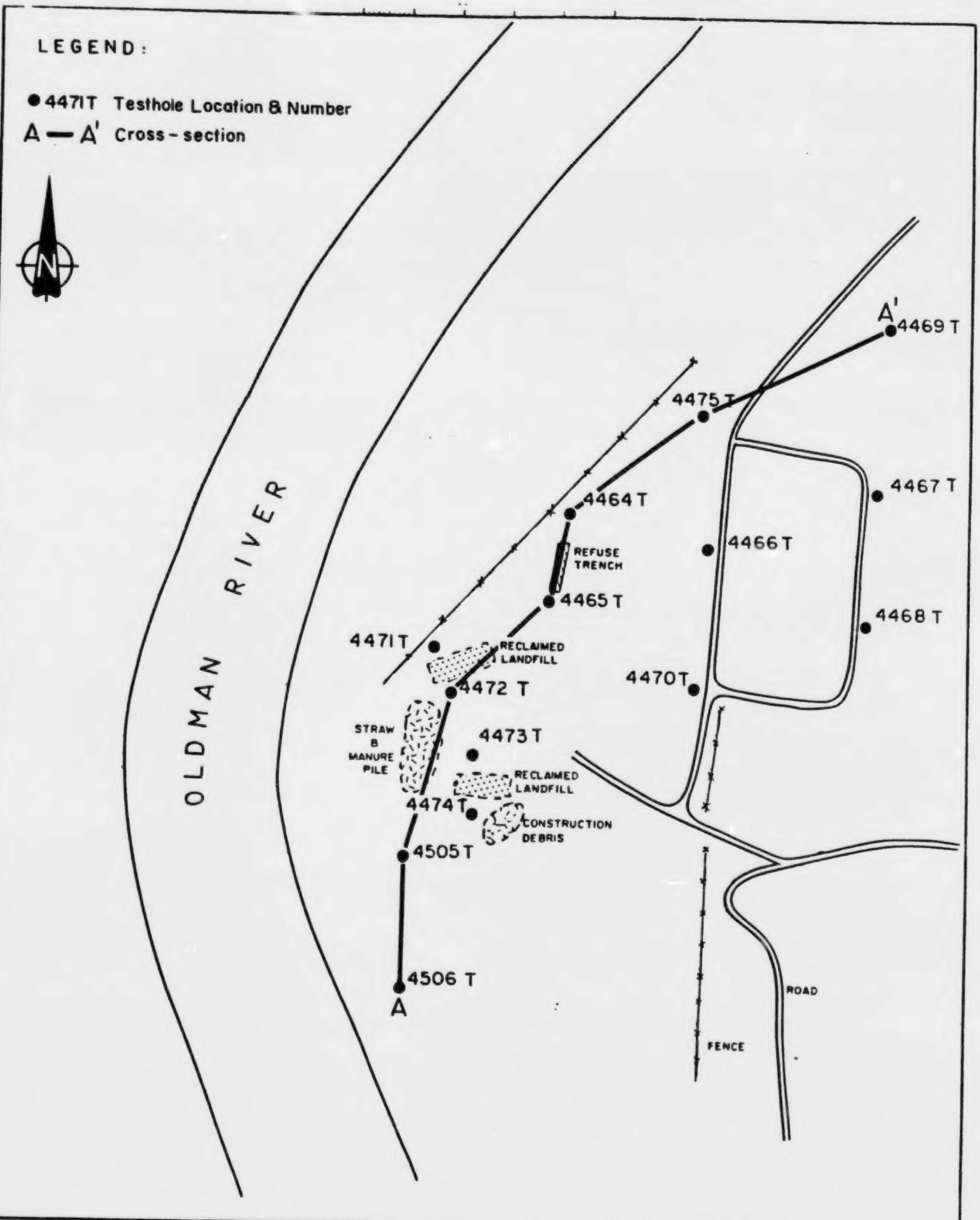
FIGURE No. 1

FILE No


LEGEND:
● 4471T Testhole Location & Number
A — A' Cross-section
N
OLDMAN RIVER
A'
4469 T
4475 T
4464 T
REFUSE TRENCH
4465 T
4467 T
4466 T
4468 T
4471T
RECLAIMED LANDFILL
4472 T
4470T
STRAW & MANURE PILE
4473 T
RECLAIMED LANDFILL
4474T
CONSTRUCTION DEBRIS
4505T
4506 T
A
ROAD
FENCE

MICROFILM DATE

DRAWING No

FILE No

Alberta
ENVIRONMENT

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APPROVED	DRAWN MD
DATE Feb 14/86	CHECKED

A.D.R.I. LANDFILL STUDY

SITE PLAN

SCALE 1-5000	SHEET OF
DATE	FIGURE No. 2

MICROFILM DATE

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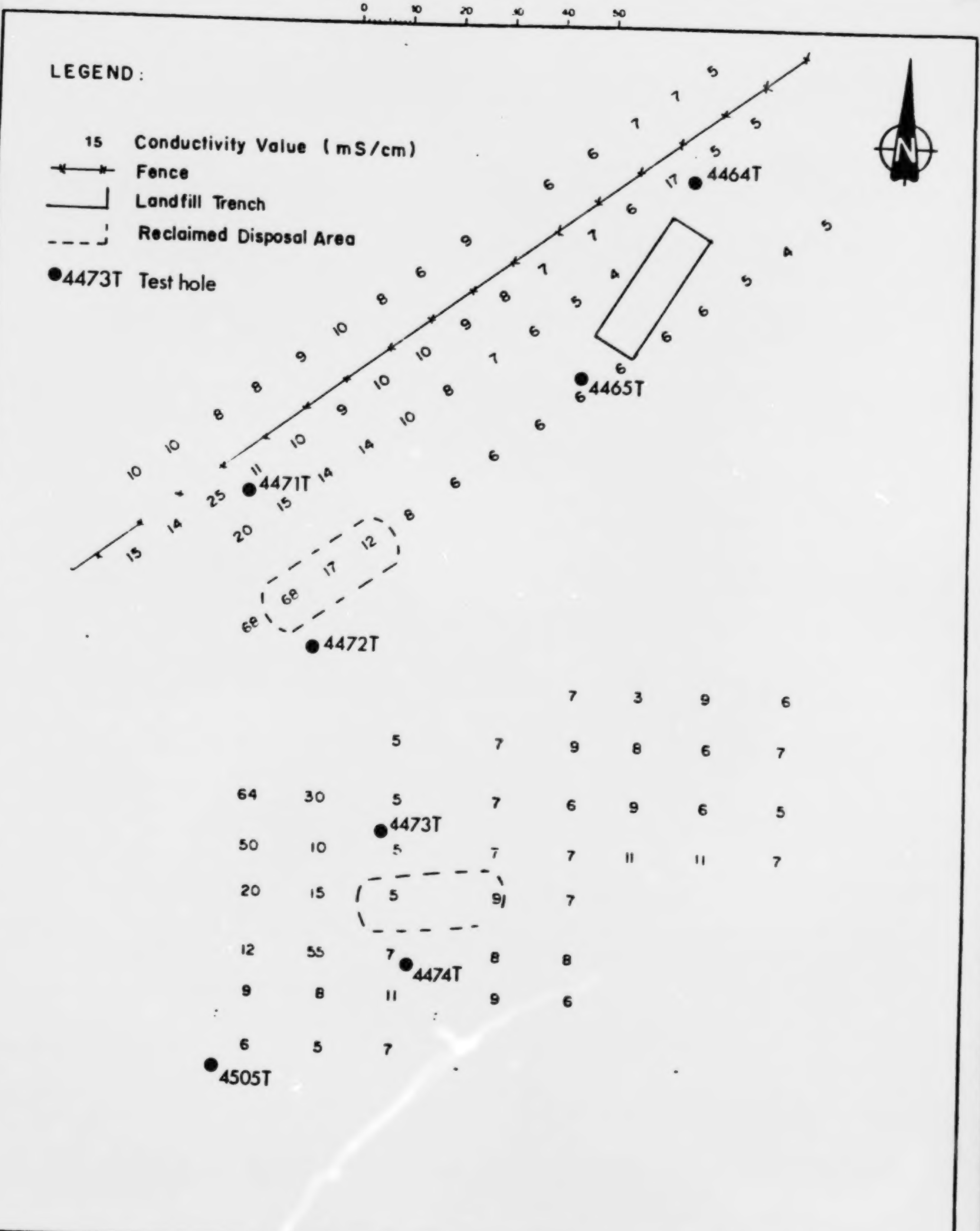
0 10 20 30 40 50
LEGEND:
15 Conductivity Value (mS/cm)
Fence
Landfill Trench
Reclaimed Disposal Area
4473T Test hole
N
4464T
4465T
4471T
4472T
4473T
4474T
4505T

ENVIRONMENT

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A.D.R.I. LANDFILL STUDY

TERRAIN CONDUCTIVITY

approx. 3 m below ground surface

SCALE 1-2500
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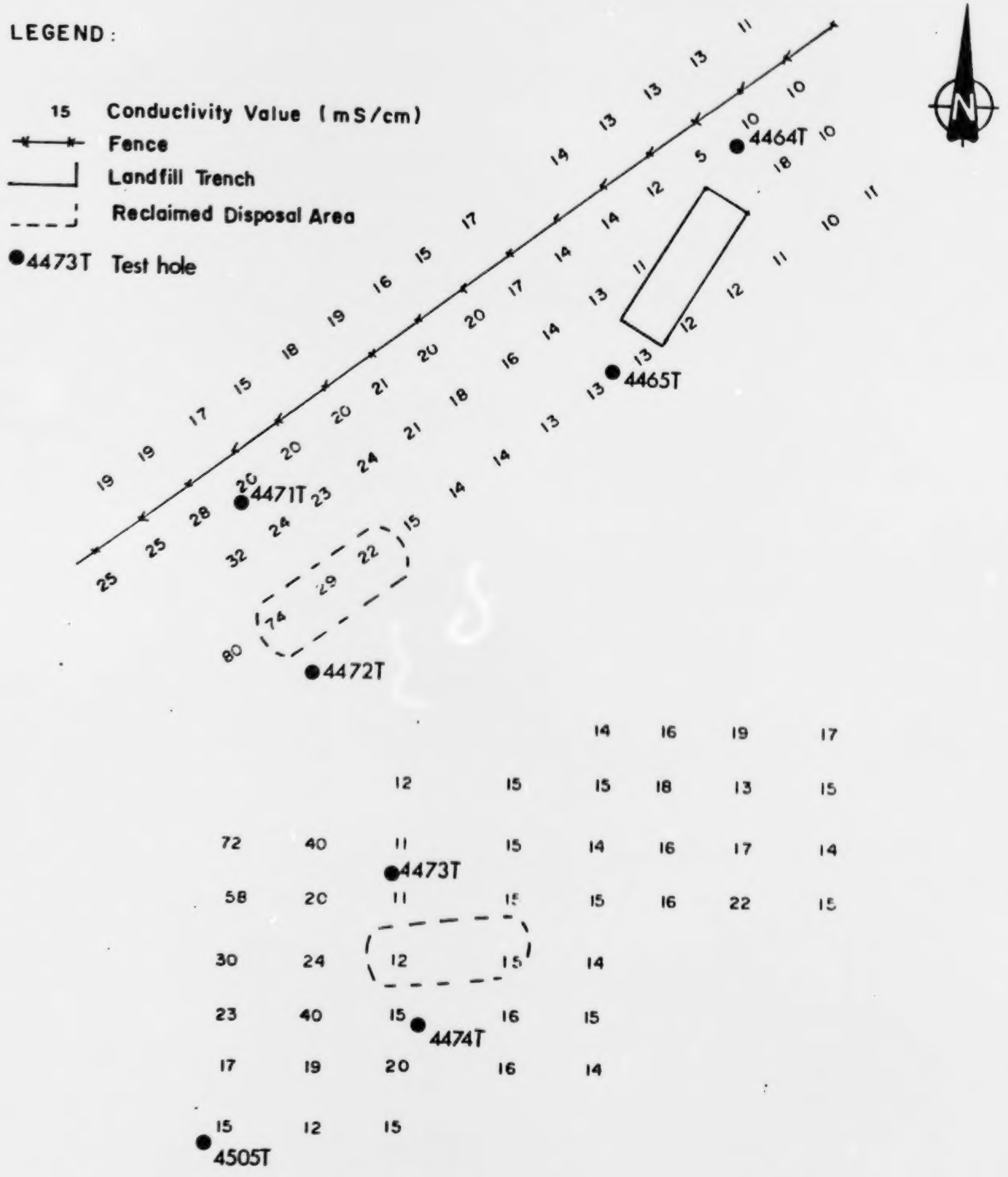
FIGURE No. 3


LEGEND:
15 Conductivity Value (mS/cm)
Fence
Landfill Trench
Reclaimed Disposal Area
4473T Test hole
N
4464T
4465T
4471T
4472T
4473T
4474T
4505T

MICROFILM DATE

DRAWING No

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A.D.R.I. LANDFILL STUDY

TERRAIN CONDUCTIVITY

approx. 6 m below ground surface

SCALE	SHEET OF
DATE	FIGURE No. 4

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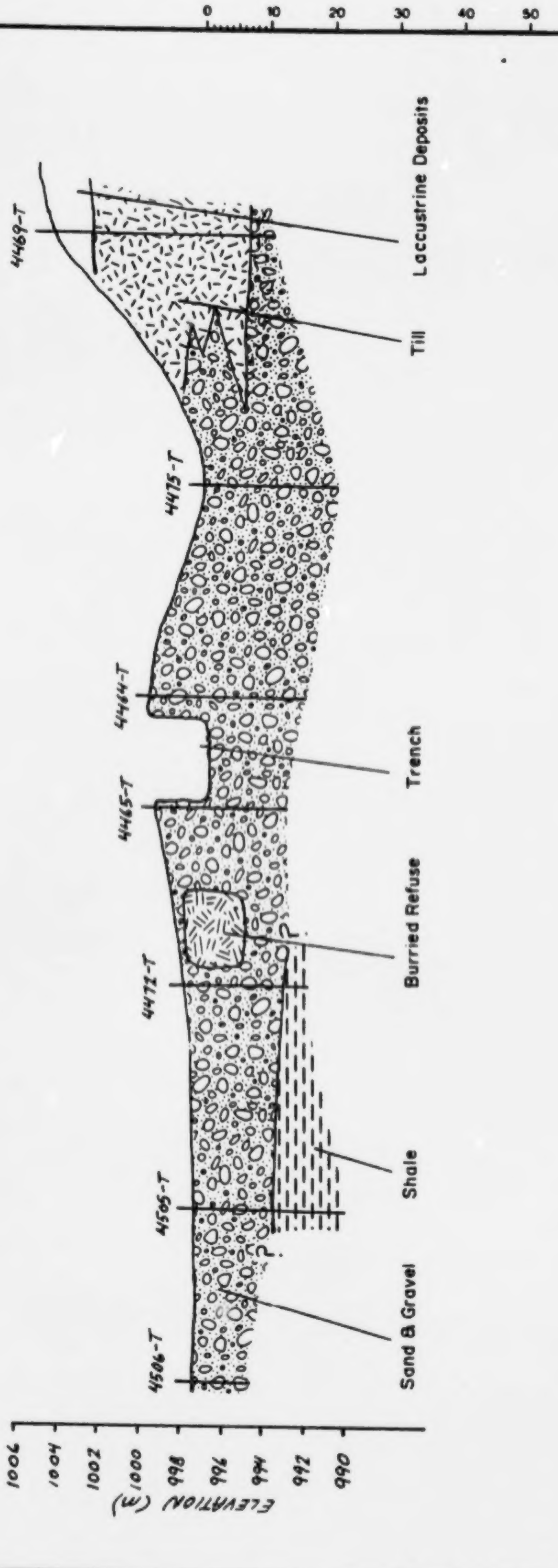
0
10
20
30
40
50
4469-T
4475-T
4464-T
4465-T
4472-T
4505-T
4506-T
Laccustrine Deposits
Till
Trench
Burried Refuse
Shale
Sand & Gravel
1006
1004
1002
1000
998
996
994
992
990
ELEVATION (m)

Alberta ENVIRONMENT		A.D.R.I. LANDFILL STUDY
SUBMITTED W. J. Cuin DATE Feb. 14 /86	DESIGNED WC CHECKED	GEOLOGIC CROSS-SECTION
APPROVED DATE Feb. 14/86	DRAWN WC CHECKED	SCALE 1— 5000 DATE
		SHEET OF FIGURE No. 5

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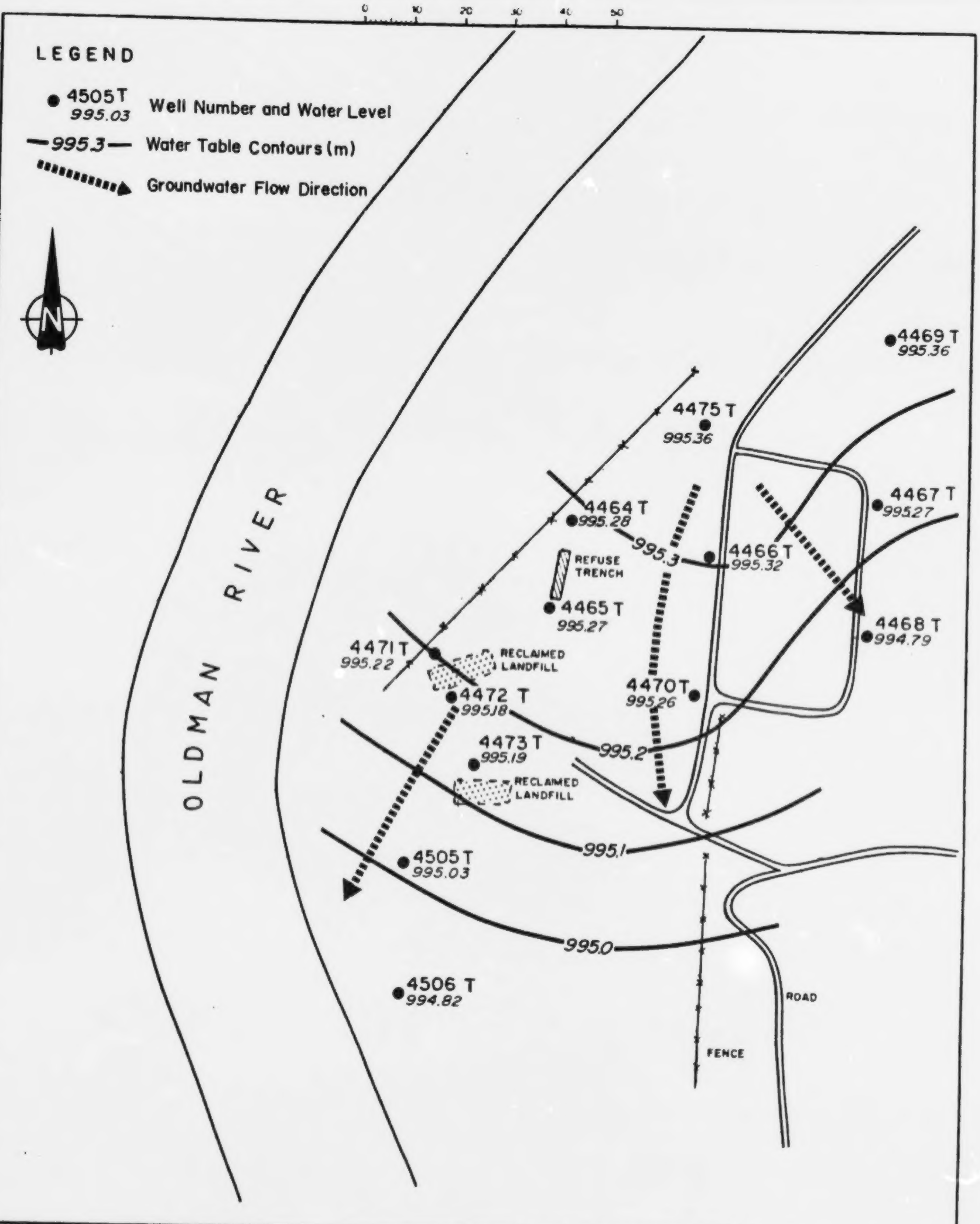

0
10
20
30
40
50
LEGEND
● 4505T 995.03 Well Number and Water Level
—995.3— Water Table Contours (m)
Groundwater Flow Direction
N
OLDMAN RIVER
4469 T 995.36
4475 T 995.36
4467 T 995.27
4464 T 995.28
995.3
4466 T 995.32
REFUSE TRENCH
4465 T 995.27
4468 T 994.79
4471 T 995.22
RECLAIMED LANDFILL
4470 T 995.26
4472 T 995.18
4473 T 995.19
995.2
RECLAIMED LANDFILL
995.1
4505 T 995.03
995.0
4506 T 994.82
ROAD
FENCE

FILE No

Alberta
ENVIRONMENT

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DATE Feb. 14 /86

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A.D.R.I. LANDFILL STUDY

WATER TABLE CONTOURS

SCALE 1-5000
DATE
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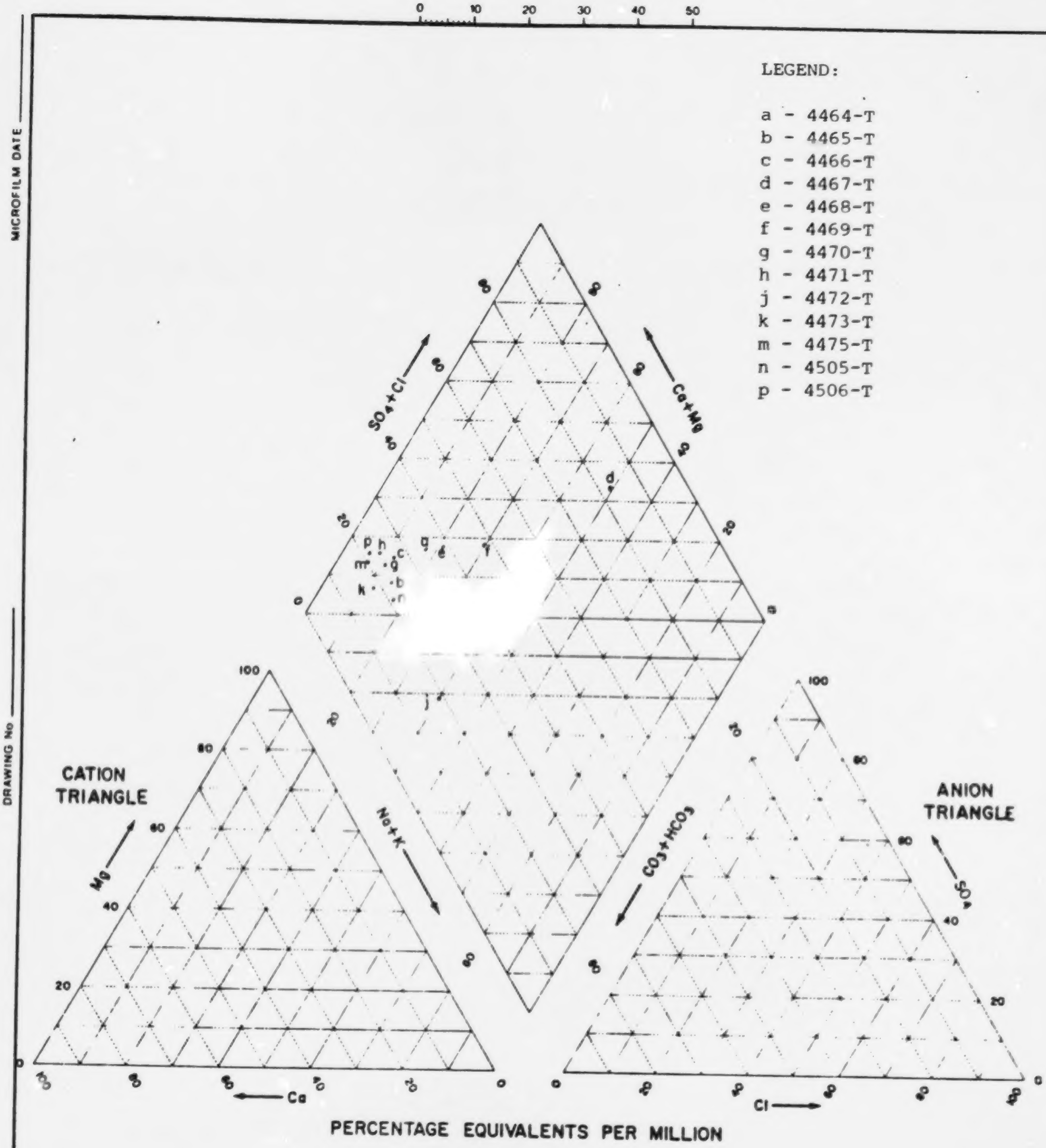
FIGURE No. 6



Alberta
ENVIRONMENT

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DATE Feb 14/86
APPROVED
DATE Feb 17/86

DESIGNED R.M.C.
CHECKED
DRAWN B.N.H. & A.B.M.
CHECKED

Modified Landfill Investigation
Animal Diseases Research Institute-Co. #26
Pt. N.E. 12-9-23-W4 (1985-10-02)
Piper Plot of Hydrochemical Analyses

SCALE N/A
DATE November 1985
SHEET OF
FIGURE No. 7

Table 1

A.D.R.I. Pt. N.E. 12-9-23-4

MONITORING WELL COMPLETION INFORMATION

Observation Well #	Type of Observation Well	Date Installed	Observation Well Depth (m)	Height of Pipe Above Ground Surface (m)	Screened Interval (m)	Ground Elevation* (m)	Elevation * Top of Pipe (m)
4464-T	WTW	1985-08-13	7.34	0.60	2.84- 7.34	999.92	1000.52
4465-T	WTW	1985-08-13	6.66	0.56	2.16- 6.66	999.54	1000.10
4466-T	WTW	1985-08-13	5.80	0.30	1.30- 5.80	999.73	1000.03
4467-T	WTW	1985-08-13	7.70	0.60	3.20- 7.70	1001.68	1002.28
4468-T	WTW	1985-08-13	6.93	0.67	2.43- 6.93	1000.66	1001.33
4469-T	WTW	1985-08-14	10.49	0.56	0.00-10.49	1004.94	1005.50
4470-T	WTW	1985-08-20	5.70	0.65	1.20- 5.70	999.23	999.88
4471-T	WTW	1985-08-16	5.89	0.57	1.39- 5.89	999.65	999.22
4472-T	WTW	1985-08-16	5.99	0.62	1.49- 5.99	998.05	998.67
4473-T	WTW	1985-08-19	5.53	0.52	1.03- 5.53	998.76	999.28
4474-T	WTW	1985-08-19	4.01	0.55	0.16- 4.01	998.99	999.54
4475-T	WTW	1985-08-20	5.74	0.63	1.24- 5.74	999.07	999.70
4505-T	WTW	1985-08-	5.68	0.42	1.18- 5.68	997.39	997.81
4506-T	WTW	1985-08-	3.24	0.51	0.74- 3.24	997.51	998.02

* Assumed Geodetic Metric

Table 2

A.D.R.I. Pt. N.E. 12-9-23-4

WATER LEVEL DATA GROUNDWATER ELEVATIONS (*ASSUMED GEODETIC METRIC)

Well Number	Type/Depth (m)	Monitor Ground Elev.* (m)	85/08/21		85/09/13		85/10/02		85/10/25		85/11/25	
			Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.
4464-T	WTW/7.34	999.92	5.18	994.74	5.07	994.85	4.90	995.02	4.76	995.16	4.64	995.28
4465-T	WTW/6.66	999.54	4.81	994.73	4.71	994.83	4.52	995.02	4.40	995.14	4.27	995.27
4566-T	WTW/5.80	999.73	4.96	994.77	4.85	994.88	4.66	995.07	4.53	995.20	4.00	995.32
4467-T	WTW/7.70	1001.68	6.90	994.78	6.83	994.85	6.64	995.04	6.54	995.14	6.41	995.27
4468-T	WTW/6.93	1000.66	6.23	994.43	6.17	994.49	6.07	994.59	5.98	994.68	5.87	994.79
4469-T	WTW/10.49	1004.94	10.12	994.82	10.04	994.90	9.85	995.09	9.72	995.22	9.61	995.33
4470-T	WTW/5.70	999.23	4.57	994.66	4.38	994.85	4.23	995.00	4.12	995.11	3.97	995.26
4471-T	WTW/5.89	998.65	4.13	994.52	3.89	994.76	3.68	994.97	3.55	995.10	3.43	995.22
4472-T	WTW/5.99	998.05	3.32	994.73	3.31	994.74	3.12	994.93	3.00	995.05	2.87	995.18
4473-T	WTW/5.53	998.76	4.11	994.65	3.98	994.78	3.83	994.93	3.71	995.05	3.57	995.19
4475-T	WTW/5.74	997.07	5.15	993.92	4.15	994.92	3.95	995.12	3.81	995.26	3.71	995.36
4505-T	WTW/5.68	997.39			2.85	994.54	2.63	994.76	2.50	994.89	2.36	995.03
4506-T	WTW/3.26	997.51			3.75	Dry	3.04	994.47	2.89	994.62	2.69	994.82

Table 3

A.D.R.I. LANDFILL INVESTIGATION
Pt. N.E. 12-9-23-W4
Groundwater Chemistry Analyses
(1985-10-02)

Well Number	WTW 4464-T	WTW 4465-T	WTW 4466-T	WTW 4467-T	WTW 4468-T	WTW 4469-T	WTW 4470-T
Lab Data							
pH	7.81	7.86	8.06	8.06	8.37	8.21	8.03
EC (mS/cm)	0.50	0.42	0.48	2.45	0.66	1.48	0.46
SAR	0.6	0.4	0.5	5.2	0.9	2.0	0.4
LAB ANALYSIS							
Inorganic (mg/L)							
Hardness	257.5	232.5	265.0	750.0	322.5	565.0	260.0
Ca	71.0	65.0	74.0	184.0	83.0	103.0	67.0
Mg	19.44	17.01	19.44	70.47	27.95	74.72	22.48
Na	23.0	16.1	18.4	331.2	36.8	108.1	13.8
HCO_3	261.08	259.86	286.09	425.17	293.41	511.79	278.16
CO_3							
CL	15.24	6.38	2.84	7.27	2.84	15.24	3.19
SO_4	68.4	50.4	66.0	1080.0	142.8	367.2	62.4
K	1.96	1.56	1.17	4.69	1.56	5.47	1.17
NO_3-N	0.022	0.066	0.066	0.31	0.38	<0.022	0.022
TDS (mg/L)	328.0	285.0	324.0	1890.0	450.0	937.0	304.0
Metals (mg/L)							
Fe	0.57	0.03	0.12	0.04	0.05	0.75	0.07
Mn	0.61	0.76	0.21	0.57	0.04	2.93	0.05
Cu	0.01	<0.01	0.01	0.02	0.04	0.01	0.01
Zn	0.02	0.02	0.02	0.14	0.02	0.02	0.02
Pb	0.04	0.04	0.03	0.48	0.04	0.04	0.03
Organic (mg/L)							
COD	22.0	47.0	.07	11.0	13.0	232.0	.06

Table 3 (Continued)

A.D.R.I. LANDFILL INVESTIGATION
Pt. N.E. 12-9-23-W4
Groundwater Chemistry Analyses
(1985-10-02)

Well Number	WTW	WTW	WTW	WTW	WTW	Oldman River	CDWS**
	4471-T	4472-T	4473-T	4475-T	4505-T	Sample	
Lab Data							
pH	8.06	8.09	7.92	8.04	8.15	7.77	
EC (mS/cm)	0.52	0.53	0.44	0.45	0.60	0.33	
SAR	0.6	1.8	0.4	0.3	0.7	0.2	
LAB ANALYSES							
Inorganic (mg/L)							
Hardness	250.0	197.5	257.5	265.0	315.0	10.00	500.0
Ca	65.0	55.0	74.0	76.0	94.0	44.0	NE***
Mg	21.26	14.58	17.62	18.23	19.44	13.37	150.0
Na	20.7	59.8	16.1	11.5	27.6	6.9	300.0
HCO_3	272.06	327.57	278.26	272.06	353.58	170.19	NE
CO_3							NE
Cl	3.19	3.19	3.19	2.48	5.67	1.60	250.0
SO_4	60.0	57.6	50.4	60.0	64.8	3.84	500.0
K	4.30	3.13	0.78	0.78	1.96	0.39	NE
NO_3-N	0.022	0.022	0.155	<0.022	1.041	<0.022	10.0
TDS (mg/L)	309.0	355.0	301.0	303.0	402.0	188.0	1000.0
Metals (mg/L)							
Fe	0.04	0.03	0.04	0.03	0.02	0.04	0.3
Mn	0.11	0.28	0.10	0.07	0.04	0.01	0.05
Cu	0.01	0.02	0.01	<0.01	<0.01	<0.01	1.0
Zn	0.02	0.02	0.01	0.01	0.02	0.01	5.0
Pb	0.04	0.02	0.03	0.02	0.04	0.02	0.5
Organic (mg/L)							
COD	.07	13.0	.02	.09	.05	<.01	

** CDWS - Canadian Drinking Water Standard
*** NE - Not Established

SOILS BRANCH DRILL HOLE LOG

Land Location Pt. N.E. Sec. 12 Tp. 9 R. 23 W 4

Date August 13 - 20, 1985 Supervisor Geoffrey E. Nash

Project A.D.R.I. Landfill Contamination Investigation

Test Hole 4464-T to 4475-T inclusive.

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Hole # 4464-T		
0.00 - 0.50	Alluvium, silty sand, beige	d
0.50 - 1.00	Alluvium, gravel and sand, beige	d
1.00 - 1.75	Alluvium, silty sand, gravel seam	d
1.75 - 2.25	Alluvium, gravel and sand, beige	d
2.25 - 3.50	Alluvium, silty sand	
3.50 - 4.75	Alluvium, gravel and sand	d
4.75 - 5.75	Alluvium, silty sand	d
5.75 - 7.50	Alluvium, gravel and sand	d
Hole # 4465-T		
0.00 - 0.50	Alluvium, fine sand, beige	d
0.50 - 0.75	Alluvium, gravel seam	d
0.75 - 1.50	Alluvium, fine to medium sand beige	d
1.50 - 3.00	Alluvium, fine to medium sand light brown, gravel caving in	sm
3.00 - 4.25	Alluvium, gravel and sand, brown	sm-m
4.25 - 5.75	Alluvium, medium sand, brown	vm

*Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Hole # 4466-T		
0.00 - 4.00	Alluvium, sandy, beige, recent deposits	d-sm
4.00 - 4.75	Alluvium, gravel and sand, gravel seams	m
4.75 - 5.25	Alluvium, gravel and sand	vm-sat
5.25 - 7.25	Till, gravelly, brown	m
7.25 - 7.50	Till, gravelly, grey	m
7.50 - 8.50	Sandstone, grey, bedrock	m
8.50 - 12.20	Shale, sandy grey	m
Hole # 4467-T		
0.00 - 0.50	Topsoil, sandy, light brown recent deposits	d
0.50 - 4.50	Alluvium, sandy clay, brown	sm-m
4.50 - 6.00	Alluvium, sandy, brown	m-vm
6.00 - 7.75	Alluvium, sandy, brown	sat
Hole # 4468-T		
0.00 - 1.50	Lacustrine, clayey, brown	d
1.50 - 3.50	Till, sandy, brown	sm-m
3.50 - 5.25	Glaciofluvial, sandy, brown	vm-sat
5.25 - 7.00	Alluvium, gravel and sand, brown	vm-sat
7.00 - 7.75	Till, clayey, brown	vm
Hole # 4469-T		
0.00 - 1.50	Lacustrine, clayey, brown	d
1.50 - 2.00	Glaciofluvial, sandy, brown	d-sm
2.00 - 7.50	Till, sandy clay, brown	m
7.50 - 10.00	Till, sandy brown	m-vm
10.00 - 11.00	Alluvium, gravel	sat

*Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Hole # 4470-T		
0.00 - 0.50	Alluvium, gravel and fine sand, brown	d
0.50 - 2.00	Alluvium, fine sand, beige	d
2.00 - 4.50	Alluvium, gravel and fine sand beige	d
4.50 - 5.75	Alluvium, gravel and cobbles, brown	vm-sat
Hole # 4471-T		
0.00 - 0.25	Alluvium, fine sand, brown silty sands	sm
0.25 - 1.30	Alluvium, fine sand, beige	d
1.30 - 1.50	Alluvium, gravel	d
1.50 - 1.80	Alluvium, fine sands, beige	d
1.80 - 3.00	Alluvium, gravel	d
3.00 - 4.25	Alluvium, gravel	m-vm
4.25 - 4.75	Alluvium, gravel	sat
4.75 - 6.00	Shale, sandy, grey	m
Hole # 4472-T		
0.00 - 0.25	Topsoil, sandy, brown	sm
0.25 - 1.75	Alluvium, fine sand, beige	d-sm
1.75 - 3.00	Alluvium, gravel	d-sm
3.00 - 3.50	Alluvium, gravel and cobbles	m-vm
3.50 - 4.75	Alluvium, gravel and cobbles	sat
4.75 - 6.00	Shale, sandy, grey	m

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*Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT[*]
Hole # 4473-T		
0.00 - 0.20	Topsoil, sandy, brown	sm
0.20 - 3.00	Alluvium, gravel and cobbles	d-sm
3.00 - 3.75	Alluvium, gravel and cobbles	vm
3.75 - 5.50	Alluvium, gravel and cobbles	sat
5.50 - 6.1	Shale, sandy, grey	m
Hole # 4474-T		
0.00 - 0.20	Topsoil, sandy, brown	sm
0.20 - 4.25	Alluvium, gravel and cobbles	sm
4.25 - 4.50	Bedrock, hard drilling	d
HOle # 4475-T		
0.00 - 0.25	Topsoil, sandy, brown	sm
0.25 - 1.50	Alluvium, fine sand, beige	d
1.50 - 3.25	Alluvium, gravel	d
3.25 - 6.10	Alluvium, gravel	sat

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[*] Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

SOILS BRANCH DRILL HOLE LOG

Land Location Pt. N.E. Sec. 12 Tp. 9 R. 23 W 4

Date August 27, 1985 Supervisor Geoffrey E. Nash

Project ADRI Landfill Contamination Investigation

Test Hole 4505-T to 4506-T inclusive.

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Hole # 4505-T		
0.00 - 0.25	Top soil, sandy clay, brown.	m
0.25 - 0.75	Alluvial, sandy clay, brown, river deposits.	m
0.75 - 2.75	Alluvial, gravel,river deposits.	sm-m
2.75 - 3.50	Alluvial, gravel and cobbles, river deposits.	s
3.50 - 6.10	Shale, clayey, grey	sm-m
Hole 4506-T		
0.00 - 0.25	Top soil, sandy clay, brown, river deposits.	m
0.25 - 3.00	Gravel and cobbles.	m-vm

*Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

CZAR LANDFILL

SE 20-40-6-W4

LOCATION AND SITE DESCRIPTION

- 0.5 km southwest of Czar (Figure 1);
- the land slopes generally southwest, away from the village;
- the entire quarter is very sandy and consequently not suitable for farming;
- site is active and receives mostly domestic garbage;
- the disposal site has an area of approximately 0.5 ac (0.2 ha).

FIELD PROGRAM

Test Drilling and Monitor Completion

- three testholes drilled at two locations (locations shown on Figure 2 and borehole logs attached);
- two water table wells and a piezometer completed at two sites (completion details contained in borehole logs).

Monitoring

- water levels recorded on September 4, 1985;

Well Number	Depth to Water (m, below ground surface)
W472	6.06
P473	7.5
W474	6.6

- groundwater samples collected on September 11, 1985 for chemical analysis (Table 1).

STUDY RESULTS

Geology

- sand, brown, medium-grained; at least 10.5 m thick, is the predominant surficial material.

Hydrogeology

- hydraulic conductivity of sand 10^{-2} - 10^{-3} cm/s (based on visual grain size analysis);

- the depth to water table in the landfill area is approximately 7 m.
- the probable direction of groundwater flow is to the southwest (based on the slope of the surface topography);
- the site is located in a groundwater recharge area (i.e., the hydraulic head decreases with depth).

Hydrochemistry

- shallow groundwater is the calcium/magnesium-bicarbonate type with a total dissolved solids concentration less than 200 mg/L;
- water is of exceptionally good quality with no parameters exceeding the Canadian Drinking Water Standards;
- water has a very low organic load (COD value of 931 mg/L for P473 is believed due to analytical error).

CONCLUSIONS

- the landfill area is underlain by clean, permeable sand, at least 10.5 m thick;
- shallow groundwater is of excellent quality and exhibits no indication of contamination.

RECOMMENDATIONS

- due to high hydraulic conductivity of the sand, it is recommended that the site no longer be used for waste disposal or at the very least only inert materials (eg. construction debris) be disposed of at the site;
- it is recommended that monitoring activities at the site cease;
- the site should be down-graded to low priority.

MICROFILM DATE

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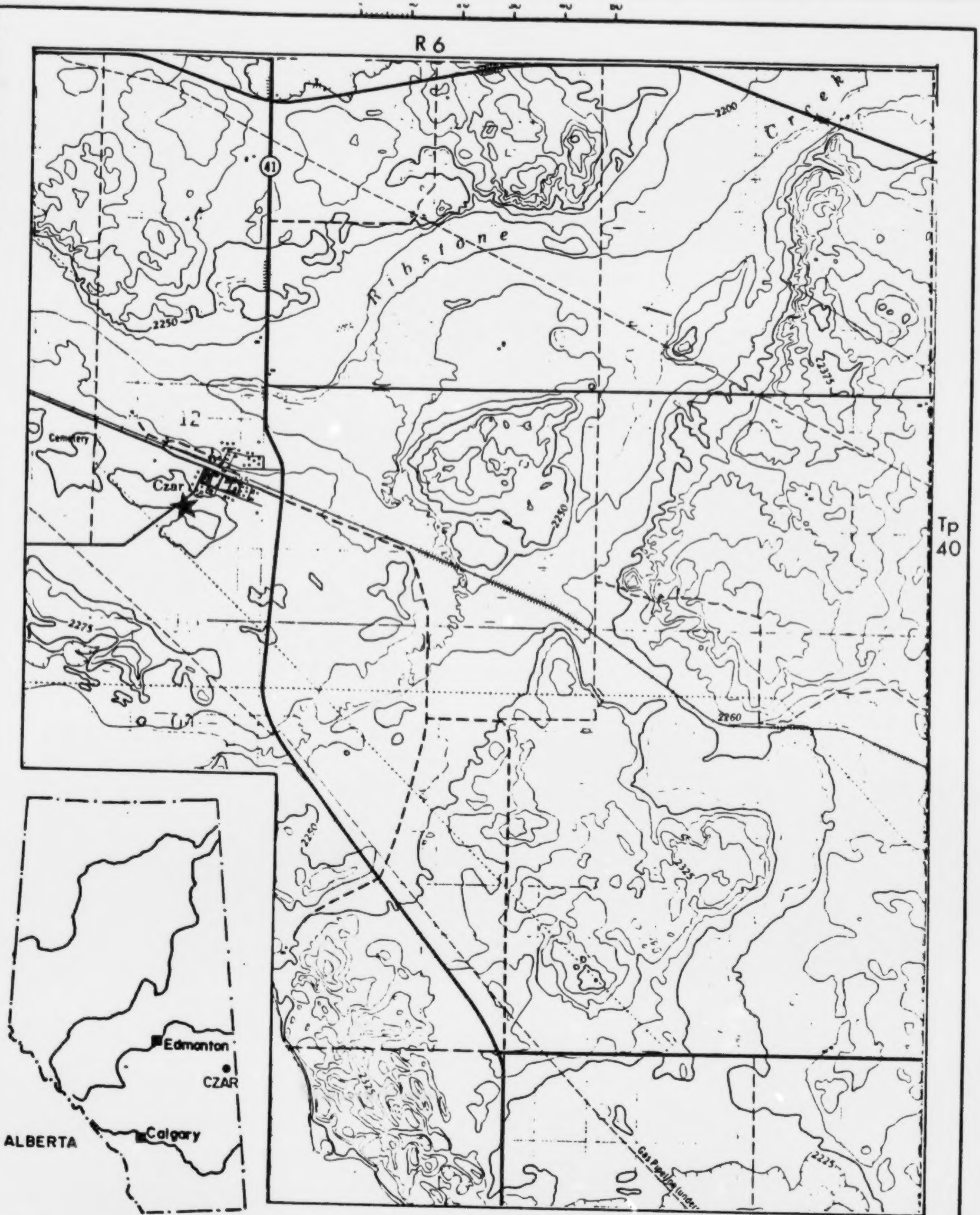
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Ribstone
Creek
41
2200
2250
2275
2260
2325
2225
12
Cemetery
Czar
Tp
40
Gas Pipeline (under)
Edmonton
CZAR
Calgary
ALBERTA

Alberta
ENVIRONMENT

SUBMITTED
DATE Feb. 14/86

APPROVED
DATE Feb. 14/86

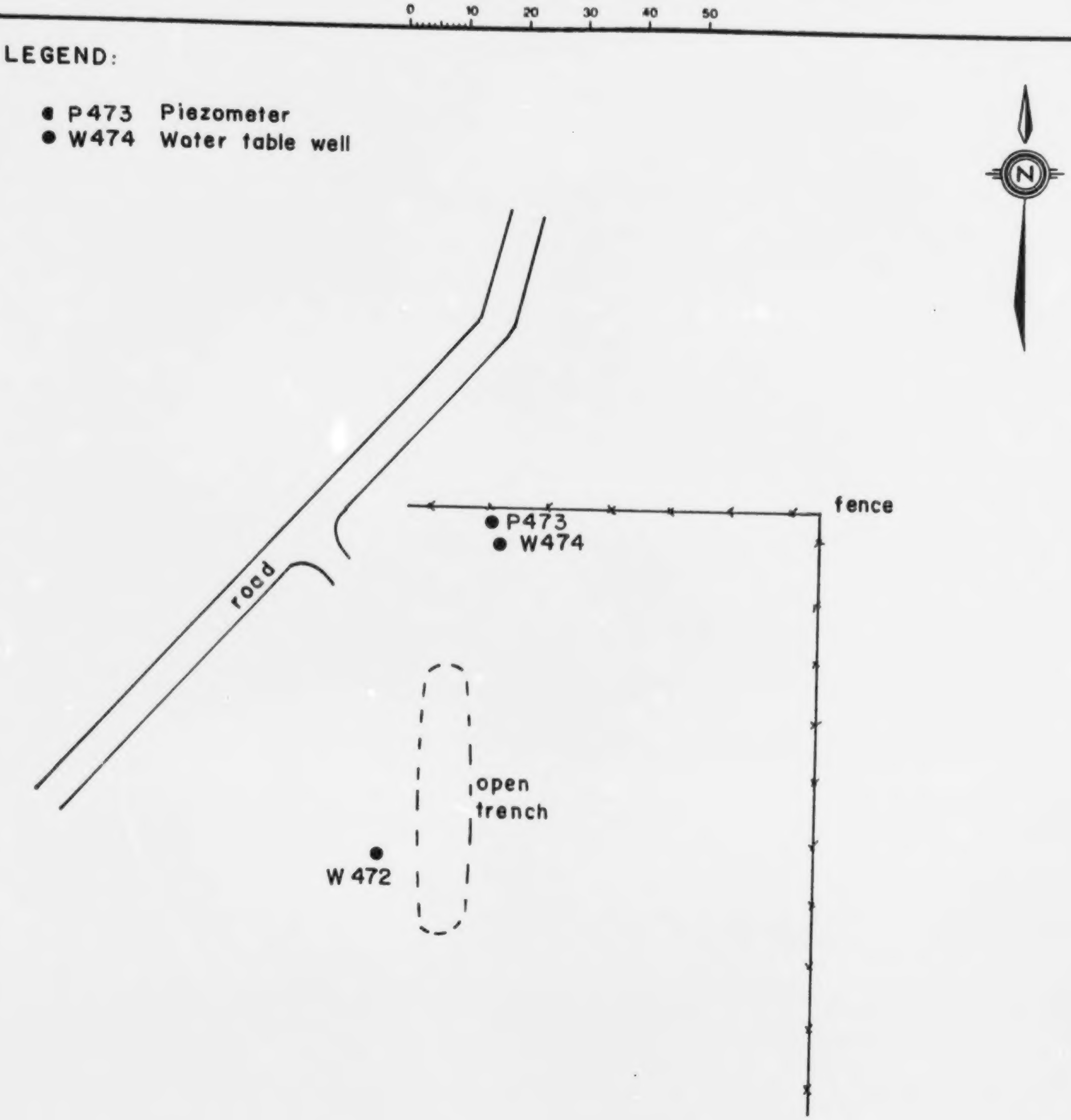
DESIGNED
CHECKED
DRAWN
CHECKED

CZAR LANDFILL

LOCATION PLAN

SCALE 1=50000
DATE
SHEET OF
FIGURE No. 1

FILE No


0
10
20
30
40
50
N
road
fence
P473
W474
open trench
W 472

LEGEND:

- ● P473 Piezometer
- ● W474 Water table well

MICROFILM DATE

DRAWING No

FILE No.

ALBERTA ENVIRONMENT

SUBMITTED	DESIGNED W C
DATE Feb 14/86	CHECKED
APPROVED	DRAWN MD
DATE Feb 14/86	CHECKED

CZAR LANDFILL

SITE PLAN

SCALE not to scale	SHEET OF
DATE	FIGURE No. 2

TABLE 1: Groundwater Chemistry Analyses

	Well Numbers 472	 473	 474	C.D.W.S.*
LAB ANALYSIS - all parameters in mg/L				
Inorganic				
Ca	43	44	50	
Mg	7.8	7.2	6	150
K	0.4	1.1	0.8	
Na	4.6	4.6	6.9	300
Cl	<0.9	1.8	1.8	250
SO_4	7.2	12	16.8	500
HCO_3	135	156	124	
NH_4-N	0.14	9.1	<0.07	1
NH_3-N	2.24	1.0	5.7	10
Total Hard.	140	140	150	500
T.D.S.	155	171	182	1000
Metals				
Fe	0.01	<0.01	<0.01	0.3
Mn	0.03	0.01	0.01	0.05
Cu	<0.01	<0.01	<0.01	1.0
Zn	<0.01	<0.01	<0.01	5.0
Pb	0.02	0.02	0.03	0.05
Organics				
TOC	12.4	N/A	2.1	
TIC	34	N/A	33.3	
COD	2	931	4	
Other				
pH	7.6	7.9	7.4	
EC (mS/cm)	0.28	0.3	0.31	
S.A.R.	0.17	0.17	0.24	

* Canadian Drinking Water Standards

SOILS BRANCH DRILL HOLE LOG

Land Location SE Sec. 20 Tp. 40 R. 6 W. 4

Date September 4, 1985 Supervisor W. Ceroici

Project Czar Landfill

Test Hole 472 to 474 inclusive.

Test Hole 472

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - 3	sand, brown, medium grained	d - sm
3 - 6	sand, brown, medium grained	sm
6 - 7.5	sand, brown, medium grained	m - vm
7.5 - 10.5	sand, brown, medium grained	s

Installation: watertable well, 10 m deep, slotted 7.5 - 10 m below ground level, 2" PVC pipe

Test Hole #473

same as #472

Installation: piezometer, 8.5 m deep, screen 8 - 8.5 m b.g.l., 2" PVC pipe

Test Hole #474

same as #472

Installation: watertable well, 7.5 m deep, slotted 4.5 - 7.5 m b.g.l., 2" PVC pipe

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DONNELLY RECLAIMED LANDFILL

SE 12-78-21-W5

LOCATION AND SITE DESCRIPTION

- the site, about 1.2 ac (0.5 ha) in area, is located approximately 1 km north of Donnelly (Figure 1);
- the landfill area, which contains primarily domestic refuse, has been reclaimed;
- the land has a gentle slope toward the northeast;
- the site is located adjacent to a canal.

FIELD PROGRAM

Test Drilling and Monitor Completion

- six testholes were drilled at five locations (locations shown in Figure 2 and borehole logs attached);
- four water table wells and a piezometer were completed at four sites (completion information contained in Table 1).

EM Survey

- a terrain conductivity survey was conducted using the EM-31 instrument in the vertical mode (approximate depth 3 m) and in the horizontal mode (approximate depth 6 m).

Monitoring

- water levels were recorded on August 19, 1985 (Table 2);
- groundwater samples were collected for chemical analysis on October 11, 1985 (Table 3).

STUDY RESULTS

Geology

- the predominant surficial materials are lacustrine clay and clay till at least 13 m thick;

- in the landfill area up to 2 m of refuse and fill overlie clay (Figure 5). Refuse may be exposed on the north slope of the canal since almost 2 m of refuse and fill was penetrated by TH 402, located adjacent to the canal.

EM Survey

- EM survey results are contained in Figure 3 and 4;
- the highest conductivity area, at both the 3 and 6 m depth, corresponds to the landfill area;
- the high conductivity area extends to the canal; this supports lithologic data which suggests that canal intersects the landfill area.

Hydrogeology

- the predominant direction of shallow groundwater flow is toward the northeast;
- the slow recovery of water levels in the wells suggest that the hydraulic conductivity of the till is very low, probably in the order of 10^{-7}cm/s;
- the site is located in a groundwater recharge area.

Groundwater Chemistry

- the analysis of groundwater samples from W399 and P398, located up-gradient from the landfill indicates that background water quality is the calcium/magnesium-sulphate type with a total dissolved solids concentration of approximately 5000 mg/L. Many constituents exceed the upper limit established for Canadian Drinking Water (see Table 3);
- only chloride and iron concentrations in leachate-contaminated groundwater from W401, completed in the refuse, exceed background values. Groundwater from the refuse is less mineralized than background water possibly because relatively fresh surface water entered the trenches when they were open.

CONCLUSIONS

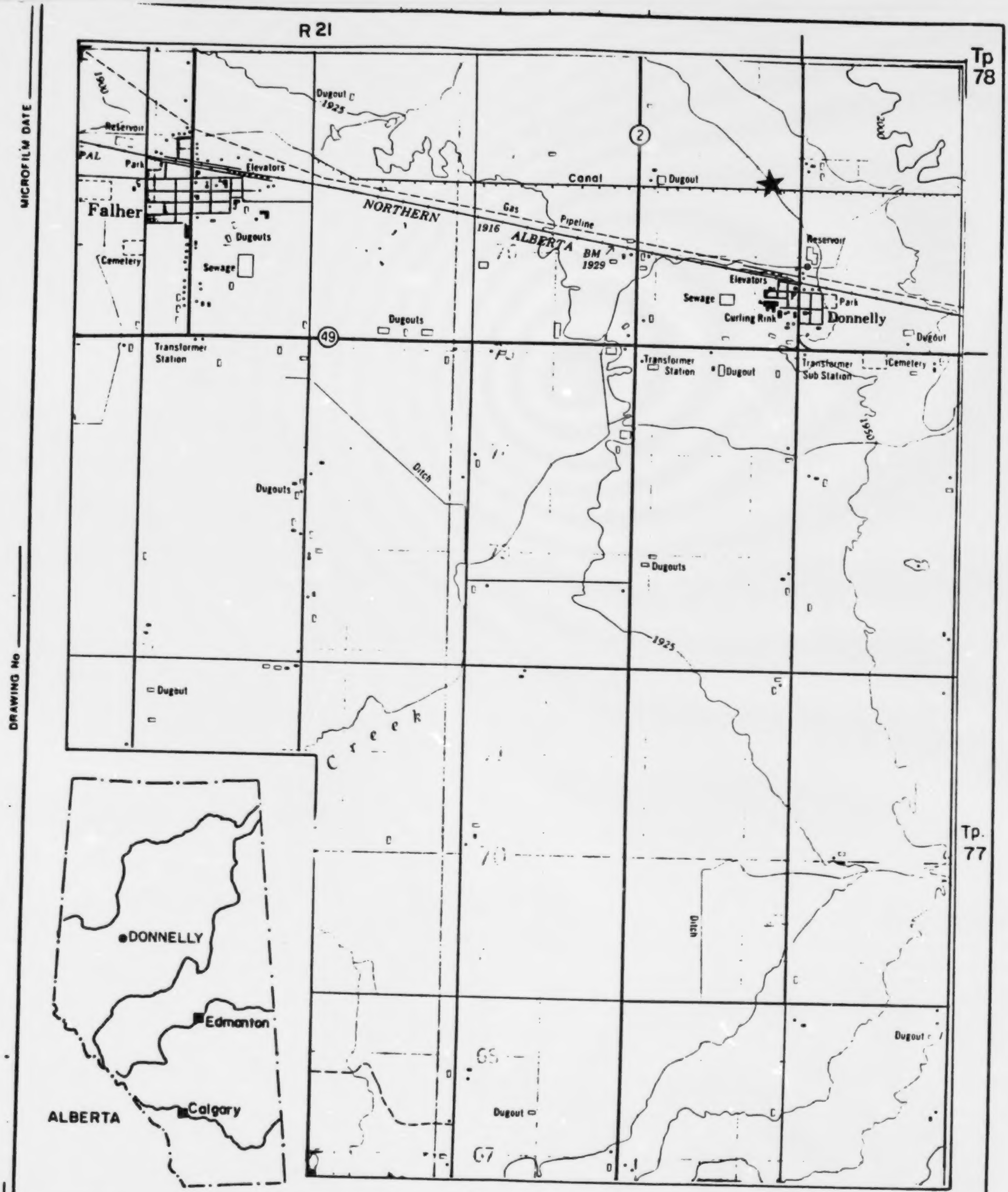
- background shallow groundwater in the area is poor quality, with numerous constituents exceeding upper limits for Canadian Drinking Water;
- leachate-contaminated water tends to have a higher chloride and iron concentration and is less mineralized than background water;
- leachate-contaminated groundwater has not, nor is it expected to pollute water in the canal due to the low hydraulic conductivity of surficial materials.

RECOMMENDATIONS

- it is recommended that monitoring activities at the site be discontinued;
- the site should be down-graded to a lower priority.

MICROFILM DATE

DRAWING No


R 21
Tp 78
Tp. 77
Reservoir
PAL
Park
Elevators
Falher
Cemetery
Dugouts
Sewage
Dugout 1925
NORTHERN ALBERTA
1916
Gas Pipeline
BM 1929
Canal
Dugout
2
49
Dugouts
Transformer Station
Reservoir
Elevators
Sewage
Curling Rink
Park
Donnelly
Dugout
Transformer Station
Dugout
Transformer Sub Station
Cemetery
Ditch
Dugouts
Dugouts
1925
1950
2000
Dugout
Creek
70
Ditch
65
67
Dugout
Dugout
DONNELLY
Edmonton
Calgary
ALBERTA

Alberta
ENVIRONMENT

DONNELLY RECLAIMED LANDFILL

LOCATION PLAN

SUBMITTED W.J. Lewis	DESIGNED
DATE Feb-14/86	CHECKED
APPROVED E. [illegible]	DRAWN
DATE Feb 14/86	CHECKED

SCALE 1:50000
DATE
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FIGURE No. 1

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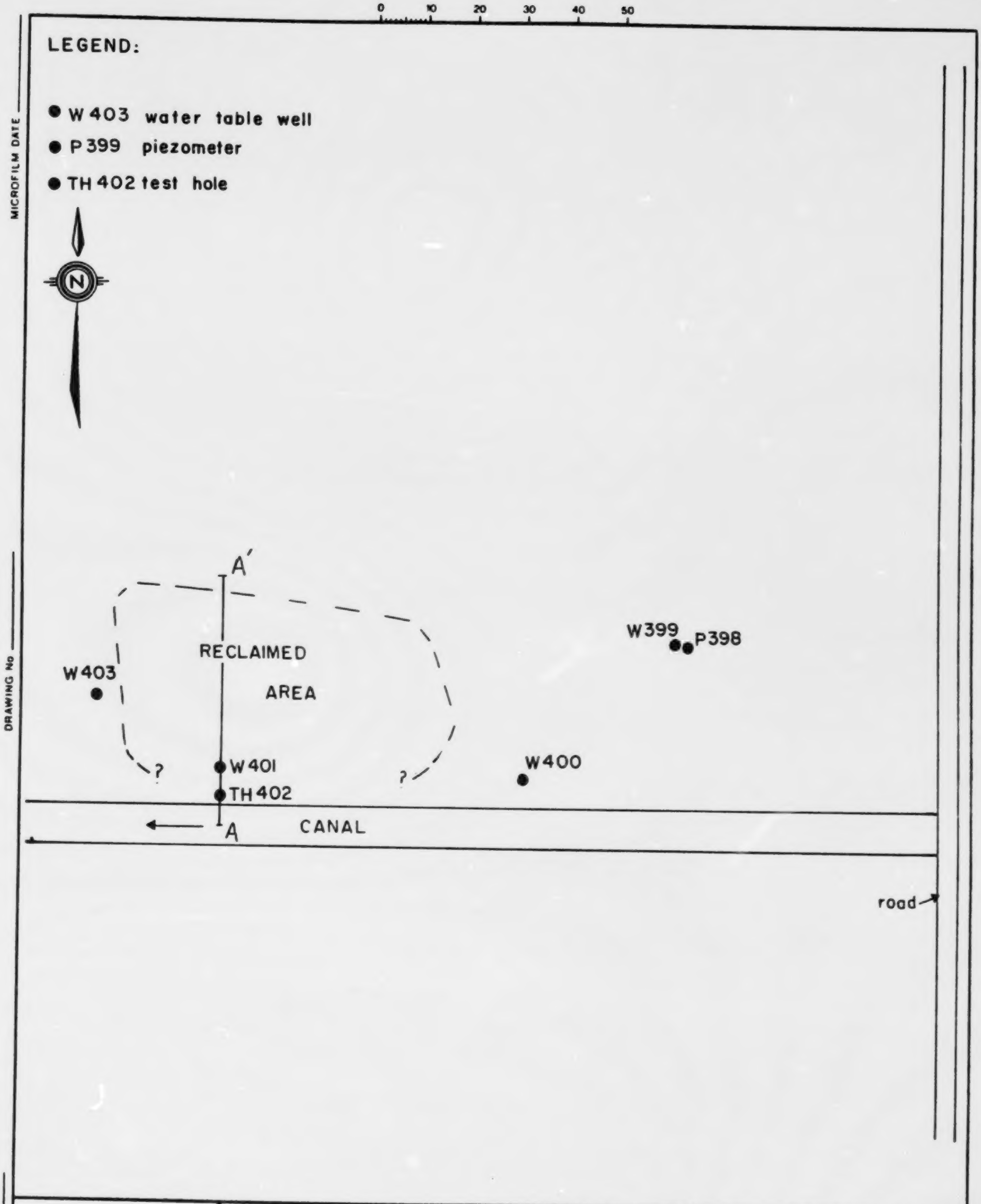
0
10
20
30
40
50
LEGEND:
● W 403 water table well
● P 399 piezometer
● TH 402 test hole
N
A′
RECLAIMED
AREA
W403
W401
TH402
?
?
W400
W399
P398
A
CANAL
road

Alberta ENVIRONMENT

SUBMITTED W. J. Gunn	DESIGNED R J
DATE Feb 14/86	CHECKED
APPROVED McCracken	DRAWN M D
DATE Feb. 14/86	CHECKED

DONNELLY RECLAIMED LANDFILL

SITE PLAN

SCALE 1=2000

DATE

SHEET OF

FIGURE No. 2

MICROFILM DATE

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MICROFILM DATE

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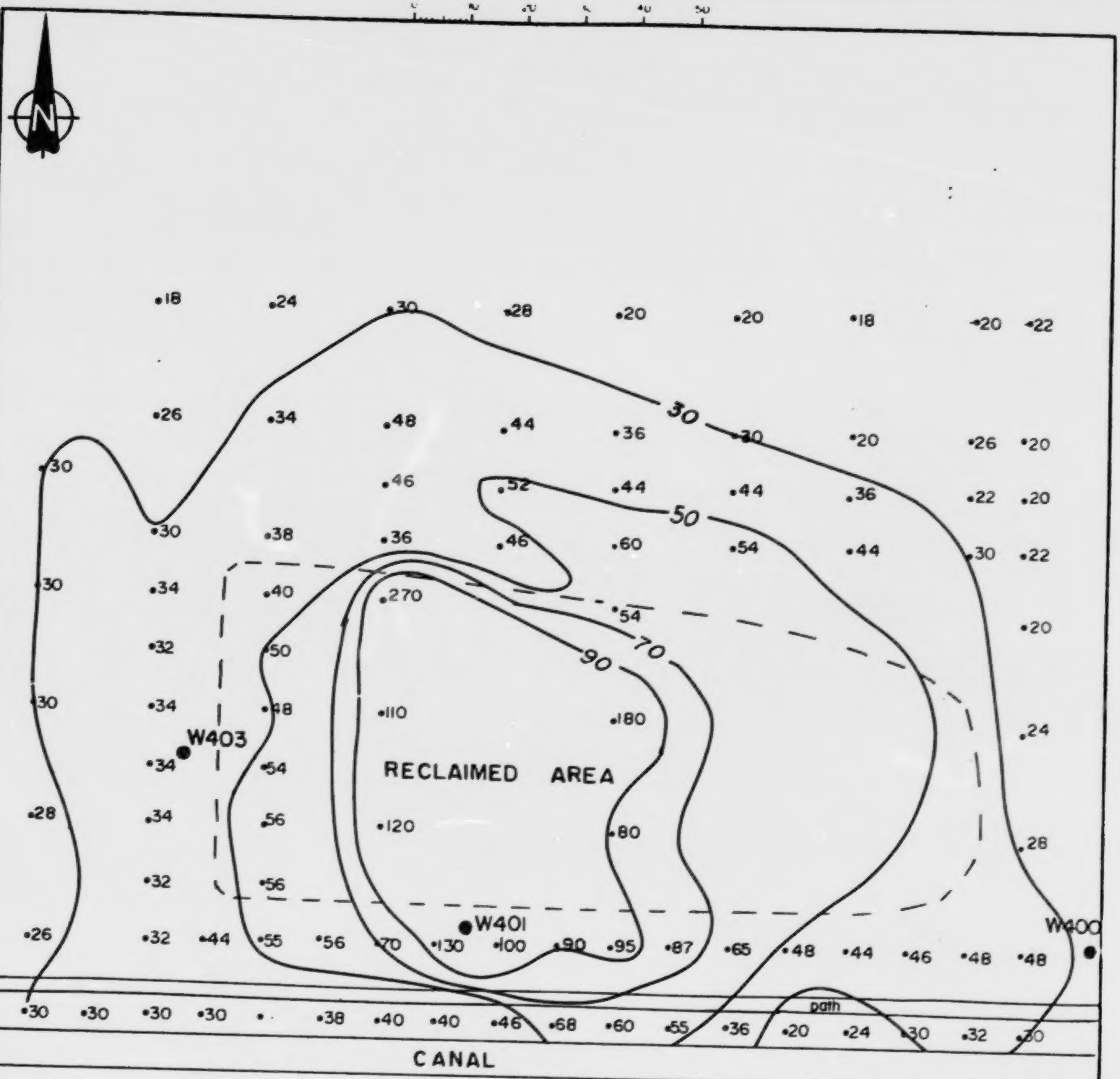

N
0
10
20
30
40
50
•18 •24 •30 •28 •20 •20 •18 •20 •22
•26 •34 •48 •44 •36 •30 •20 •26 •20
•30 •46 •52 •44 •44 •36 •22 •20
•30 •38 •36 •46 •60 •54 •44 •30 •22
•30 •34 •40 •270 •54 •20
•32 •50
•30 •34 •48 •110 •180 •24
W403
•34 •54
RECLAIMED AREA
•28 •34 •56 •120 •80 •28
•32 •56
W401
W400
•26 •32 •44 •55 •56 •70 •130 •100 •90 •95 •87 •65 •48 •44 •46 •48 •48
•30 •30 •30 •30 •38 •40 •40 •46 •68 •60 •55 •36 •20 •24 •30 •32 •30
path
30
50
70
90
CANAL

LEGEND:

W403 Water table well
• 30 Measuring station (mS/cm)
—90— Terrain conductivity contours

Alberta
ENVIRONMENT

SUBMITTED W. J. Lewis DATE Feb. 14 '86	DESIGNED CHECKED
APPROVED [illegible] DATE Feb. 14 /86	DRAWN CHECKED

DONNELLY RECLAIMED LANDFILL

TERRAIN CONDUCTIVITY (3 m bgl)

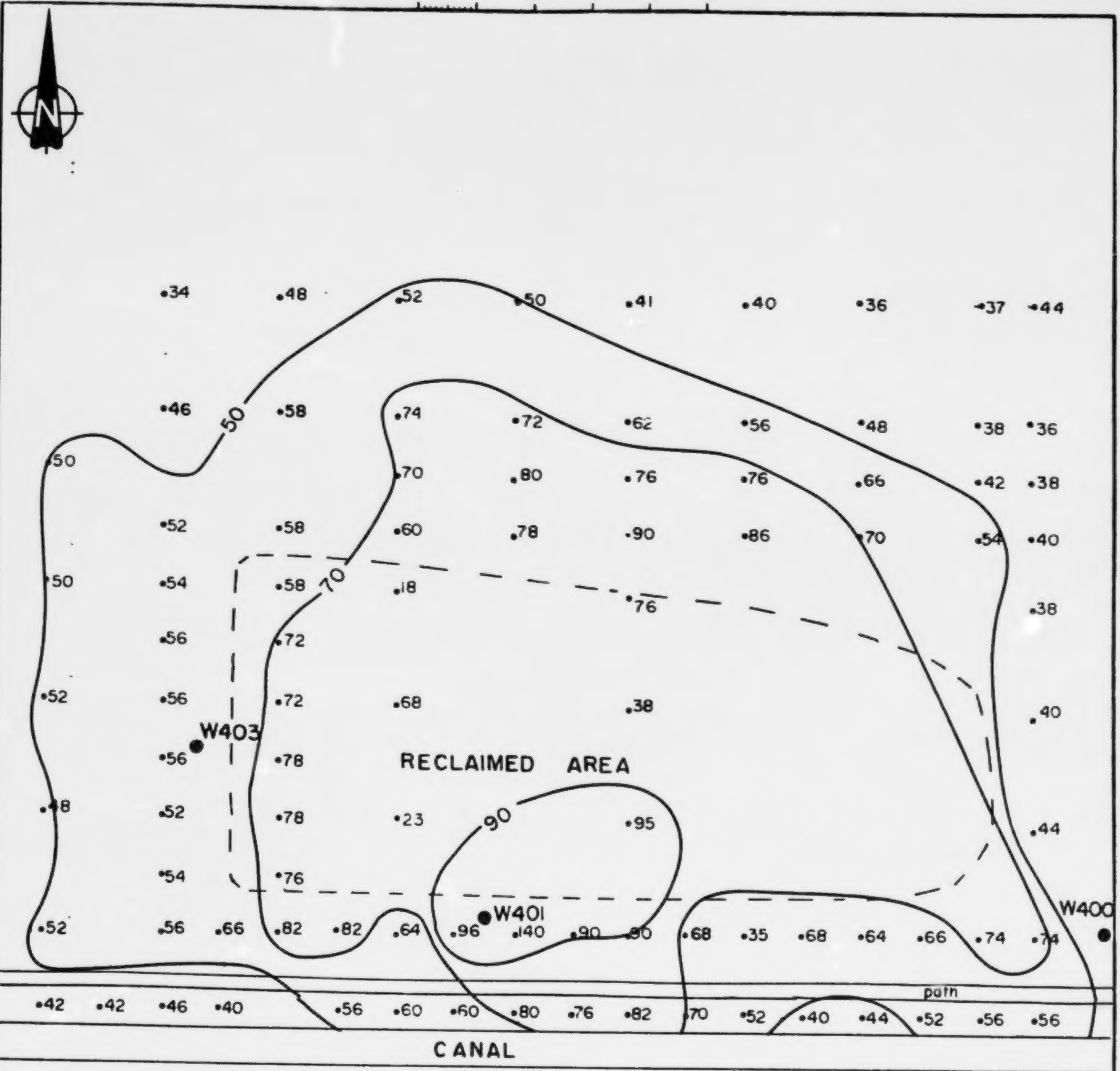
SCALE 1:1250 approx.	SHEET OF
DATE	FIGURE No. 3

FILE No.

MICROFILM DATE

DRAWING No

FILE No.


N
•34 •48 •52 •50 •41 •40 •36 •37 •44
•46 •58 •74 •72 •62 •56 •48 •38 •36
50 •70 •80 •76 •76 •66 •42 •38
•52 •58 •60 •78 •90 •86 •70 •54 •40
•50 •54 •58 •18 •76 •38
•56 •72
•52 •56 •72 •68 •38 •40
W403
•56 •78
RECLAIMED AREA
•48 •52 •78 •23 •95 •44
•54 •76
W401
W400
•52 •56 •66 •82 •82 •64 •96 •140 •90 •80 •68 •35 •68 •64 •66 •74 •74
path
•42 •42 •46 •40 •56 •60 •60 •80 •76 •82 •70 •52 •40 •44 •52 •56 •56
CANAL
50
70
90

LEGEND:

W403	Water table well
•56	Measuring station (mS/cm)
—50—	Terrain conductivity contours

Alberta
ENVIRONMENT

SUBMITTED W. A. Gun
DATE Feb. 14/86
APPROVED
DATE Feb. 14/86

DESIGNED
CHECKED
DRAWN
CHECKED

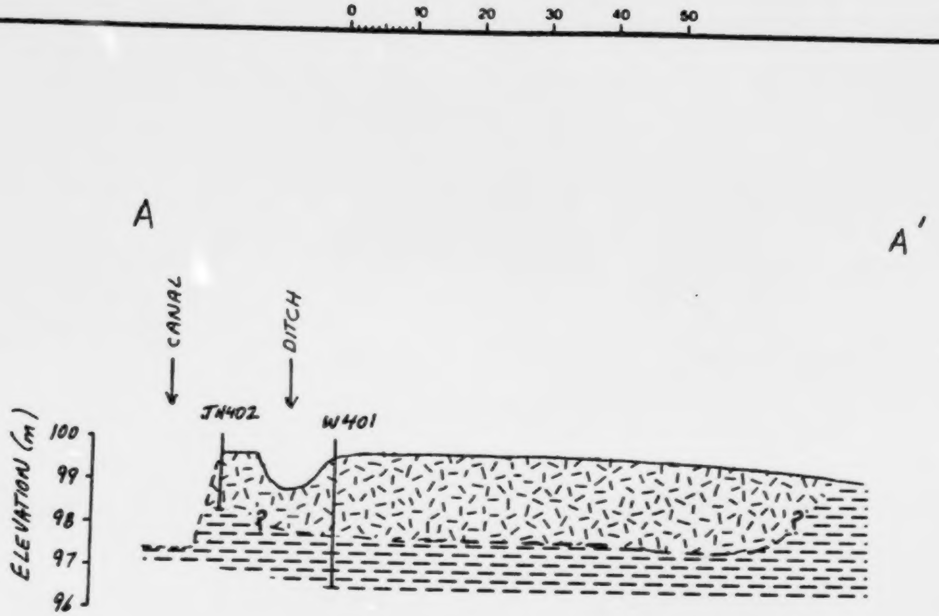
DONNELLY RECLAIMED LANDFILL

TERRAIN CONDUCTIVITY (6m bgl)

SCALE 1:1250 approx.
SHEET OF
DATE
FIGURE No. 4

MICROFILM DATE

DRAWING No


0
10
20
30
40
50
A
A'
CANAL
DITCH
JN402
W401
ELEVATION (m)
100
99
98
97
96
?
?

LEGEND

▨ REFUSE AND FILL

▤ TILL

?- - -? APPROXIMATE CONTACT BETWEEN REFUSE AND CLAY

HORIZONTAL SCALE 1:1000

Alberta
ENVIRONMENT

SUBMITTED
DATE Feb 14/86
APPROVED
DATE Feb 14/86

DESIGNED W. J. C.
CHECKED
DRAWN W. J. C
CHECKED

DONNELLY RECLAIMED LANDFILL

GEOLOGIC CROSS-SECTION A-A'

SCALE
DATE
SHEET OF
FIGURE No. 5

FILE No.

TABLE 1: MONITORING WELL COMPLETION

Well Number	Date Installed	Well Depth (m)	Height of pipe above ground surface (m)	Screened interval (m)	Ground elevation (m)	Elevation of pipe (m)	Pipe diameter (m)
P398	27 7 85	12	.75	11.5 - 12	99.84	100.59	50
W399	27 7 85	9	1.06	3 - 9	99.88	100.94	50
W400	27 7 85	7.5	.86	3 - 7.5	99.36	100.22	50
W401	27 7 85	3	1.11	1 - 3	99.67	100.78	50
W403	27 7 85	4.5	1.08	1.5 - 4.5	99.60	100.68	50

TABLE 2: WATER LEVEL DATA (85 10 09)

Well Number	Water level (m) (below ground level)
P398	11.46
W399	8.46
W400	6.38
W401	0.72
W403	2.71

TABLE 3: WATER ANALYSIS RESULTS

	Well Numbers					
	W499	W401	W403	P398	W399	C.D.W.S.*
LAB DATA						
pH	7.67	7.58	7.95	8.14	8.03	
EC (mS/cm)	3.44	3.78	3.63	4.88	6.15	
SAR	1.8	2.7	2.0	4.4	5	
LAB ANALYSIS (all parameters in mg/L)						
Inorganic						
Ca	494	242	500	484	394	NE
Mg	189.6	252	211.2	247.6	533.8	150
$CaCO_3$(T.Hard)	2225	1655	2130	2240	3205	500
Na	189.4	251.8	212.5	480.5	651.4	300
K	10.56	102.8	10.56	14.8	17.6	NE
HCO_3	483.73	781.41	566.69	799.1	803.3	NE
$CaCO_3$(T.Alk)	396.5	640.5	464.5	644	658.5	500
SO_4	1896	1284	1896	2400	3969	500
Cl	7.98	226.17	70.01	35.45	17.73	250
NO_3-N+NO_2-N	.07	.7	.28	.07	.07	10
NO_4-N	.49	1.47	.14	4.69	1.89	0.5
TDS	3025	2170	3177	4056	5314	1000
Organic						
COD	37	88	49	355	99	
Metals						
Fe	.03	1.88	.05	.09	.21	.03
Mn	1.92	1.87	.07	3.65	4.4	0.05
Cu	.02	.61	.02	.03	.03	1.0
Zn	.08	.02	.11	.09	.04	5.0
Pb	.03	.05	.02	.02	.14	0.05

* Canadian Drinking Water Standards

** Not Established

SOILS BRANCH DRILL HOLE LOG

Land Location SE Sec. 12 Tp. 78 R. 21 W 5

Date July 27, 1985 Supervisor R.J.

Project Abandoned Landfill Investigation - Donnelly

Test Hole 85-398 to 85-403 inclusive.

Test Hole 398 (P)

DEPTH (m)	DEPOSIT	DESCRIPTION	M.C.*
0.0-0.2	topsoil	light brown, silty	
0.2-1.5	clay	brown, silty, trace of white deposits	sm
1.5-2.7	clay till	grey-brown, sandy, fine textured, trace of thin fine snad & silt partings, stiff, medium plastic	sm
2.7-7.3	clay till	a/a, darker	sm - m
7.3-9.4	clay till	a/a, numerous grey pockets	sm - m
9.4-11.0	clay till	a/a, very stiff	sm - m
11.0-12.2	clay till	a/a, grey, a few brown pockets	sm - m

Dry at completion
Completed: 50 mm PVC piezometer
screened interval: 11.5 - 12.0 m (0.52 m)

Test Hole 399 (W)

0.0-9.1 same as TH 398 (P)

Dry at completion
Completed: 50 mm PVC watertable well
slotted interval: 2.9 - 9.0 m

*M.C. (Moisture Content): d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

#123

DEPTH (m)	DEPOSIT	DESCRIPTION	M.C.*
Test Hole 400 (W)			
0.0-0.3	fill	brown & grey, clay	
0.3-0.5	topsoil	light brown, silty, trace of organics	d
0.5-2.4	clay	brown & grey, trace of silt & oxide lined partings & white deposits, firm, high plastic	sm - m
2.4-3.3	clay till	brown & grey, mottled, very fine textured, trace of crystals, infrequent pebbles, stiff, high plastic	sm - m
3.3-6.1	clay till	a/a, a few grey pockets, oxides, not mottled	sm - m
6.1-7.6	clay till	a/a, grey, a few brown pockets, trace of crystals	sm - m

Dry at completion
Completed: 50 mm PVC watertable well
slotted interval: 2.7 - 7.3 m

Test Hole 401 (W)

0.0-0.3	fill	brown, clay	
0.3-1.5	garbage	black, some clay and organics	s
1.5-3.0	clay	brown & grey, firm, high plastic	vm

Water & slough at 1.5 m at completion
Completed: 50 mm PVC watertable well
slotted interval: 0.7 - 2.8 m

Test Hole 402

0.0-1.5	garbage	a lot of wire, unstable bank	d

Abandoned hole

*M.C. (Moisture Content): d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	DEPOSIT	DESCRIPTION	M.C.*
Test Hole 403 (W)			
0.0-0.5	fill	brown, clay	
0.5-0.8	topsoil	light brown, silty	d
0.8-1.5	clay	grey, numerous thin silt seams, trace of oxides, stiff, high plastic	d - sm
1.5-2.7	clay	brown & grey, very silty, numerous thin silt lenses, firm, meidum plastic	vm
2.7-4.6	clay till	dark grey-brown, sandy, firm, medium-high plastic	m

Dry at completion
Completed: 50 mm PVC watertable well
slotted interval: 1.3 - 4.3 m

*M.C. (Moisture Content): d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

EDSON MUNICIPAL LANDFILL

NE 09-53-17-W5

LOCATION

- the site, approximately 5 ac (2 ha) in area, is located about 1 km south of Edson;
- the site is active;
- the Town of Edson is currently assessing alternative sites.

FIELD PROGRAM

Test Drilling and Monitor Completion

- eight testholes were drilled (location shown in Figure 2)(bore hole logs attached);
- no testholes were drilled to the south and east of the site due to access problems;
- six water table wells and one piezometer were installed at six locations (completion details - Table 1).

Monitoring

- water levels were recorded on July 19, 1985 (Table 2);
- ground water samples were collected for chemical analysis on August 22, 1985 (Table 3).

STUDY RESULTS

Geology

- information from domestic water well logs in the vicinity of the landfill indicate overburden, approximately 30 m thick, consisting of glacial clay tills and lacustrine clays. In the landfill area, a preglacial channel, having a west-east orientation, cuts into the subcropping bedrock of sandstone and mudstone;
- the drilling program revealed a layer of plastic, silty clay at a depth of 5 to at least 7 m. This clay is overlain by organic soils (peatmoss) at the western perimeter and by silty sand at the north and northeast of the site;

- The refuse was initially deposited into excavated cells. Due to a high water table this procedure was abandoned and the landfill is now operated as an area fill, where refuse is laid down directly on the natural surface (muskeg) and covered with a layer of silty clay.

Hydrogeology

- shallow groundwater flow is towards the southeast;
- the depth to water table is approximately 1 m;
- the southern part of the site is covered by muskeg;
- hydraulic conductivity of shallow surficial deposits is high, in the order of 10^{-4}, below 7 m it is low, in the order of 10^{-7}.

Groundwater Chemistry

- background water is predominantly of the calcium-magnesium/ bicarbonate type with a total dissolved solids of less than 600 mg/L. High values for iron and manganese at well W253 cannot be readily explained and might be due to erroneous analysis;
- groundwater from wells adjacent to refuse (W250 and to a lesser extent W251 and 249) exhibits elevated values for chlorides, total hardness and alkalinity, TDS, and organic compounds suggesting that the water is contaminated;
- groundwater from P248, located at the same location as W249 but at a greater depth, is much better quality than groundwater from W249 suggesting that the level of contamination decreases rapidly with depth;
- chemical constituents of groundwater away from the refuse do not exceed upper limits as per Canadian Drinking Water Standards.

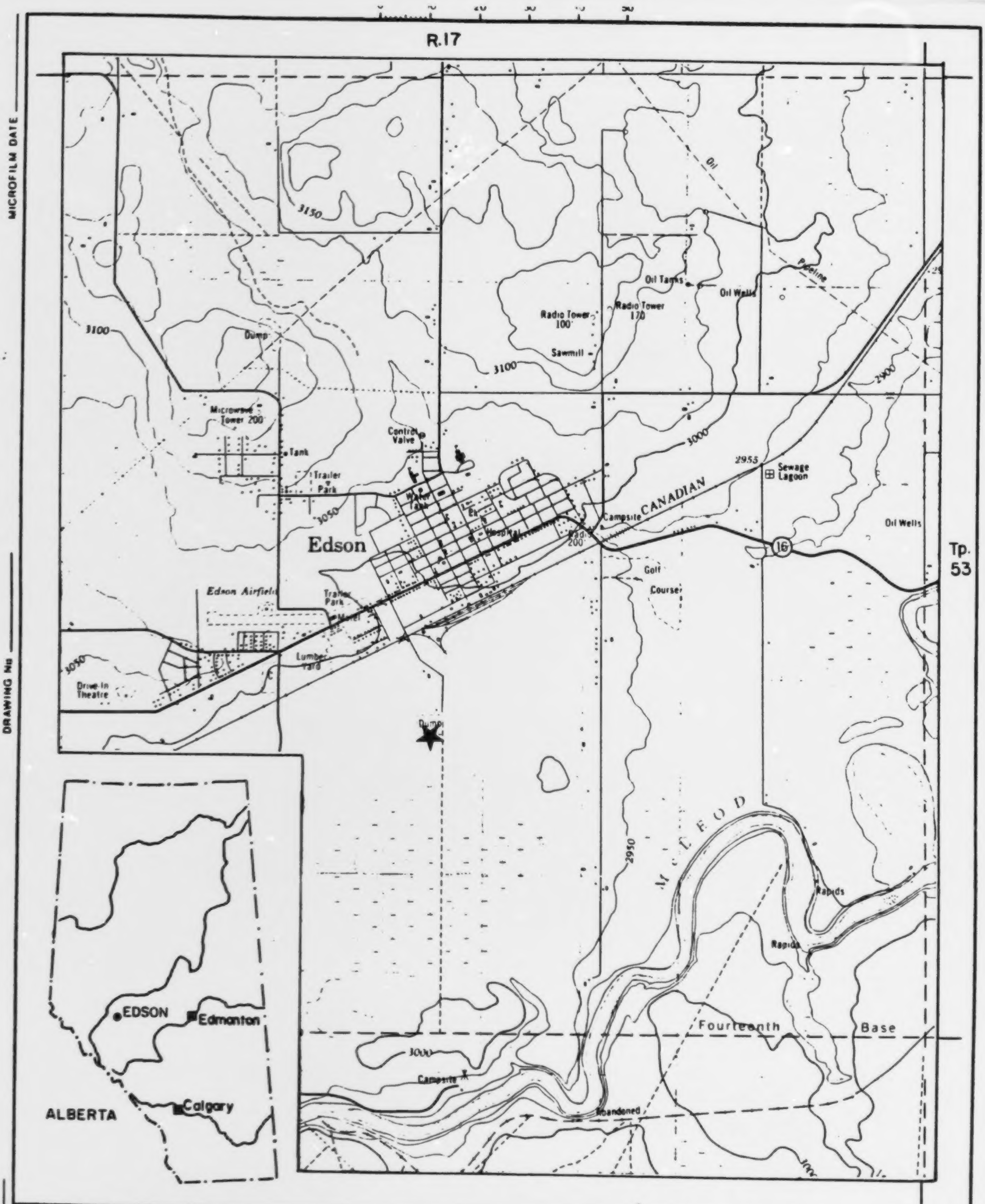
CONCLUSIONS

- groundwater in close proximity to the refuse is slightly contaminated with inorganic and organic compounds, the level of contamination decreases rapidly with depth;
- groundwater at the western and northeastern periphery of the site does not appear to be affected;

- a low surface gradient and the low hydraulic conductivity of the underlying clay material should limit the lateral and vertical movement of leachate-contaminated groundwater from the site.

RECOMMENDATIONS

- it is recommended that replicate samples be collected from the wells in 1986 to confirm low groundwater contamination;
- additional monitoring wells will be installed in February or March 1986 south of the landfill, in the muskeg area, to establish shallow groundwater quality;
- some remedial action may be necessary to prevent the contamination of surface water with contaminated water from the cut-off ditch constructed on the east and south sides of the dump area.


R.17
Tp. 53
Edson
Edson Airfield
3150
3100
3050
3000
2955
2950
2900
Oil
Pipeline
Oil Tanks
Oil Wells
Radio Tower 100
Radio Tower 170
Sawmill
Dump
Microwave Tower 200
Tank
Control Valve
Water Tank
Trailer Park
Hospital
Radio 200
Campsite
CANADIAN
Sewage Lagoon
16
Golf Course
Motel
Lumber Yard
Drive-In Theatre
Dump
McLEOD
Rapids
Rapids
Fourteenth Base
Campsite
Abandoned
EDSON
Edmonton
Calgary
ALBERTA
MICROFILM DATE
DRAWING No
FILE No

Alberta
ENVIRONMENT

SUBMITTED	DESIGNED
DATE Feb 14/86	CHECKED
APPROVED	DRAWN
DATE Feb. 14/86	CHECKED

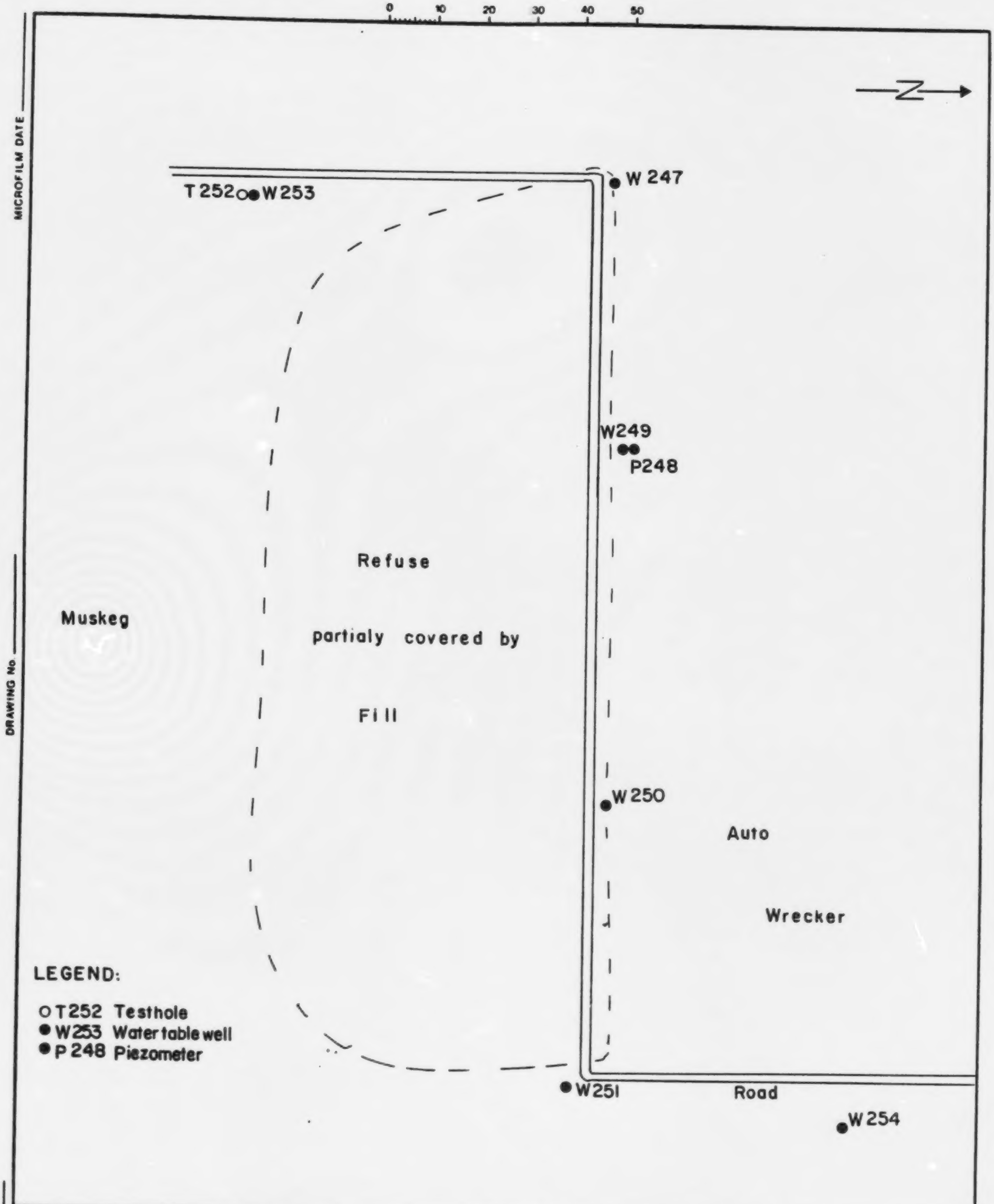
EDSON SANITARY LANDFILL

LOCATION PLAN

SCALE 1 = 50000	SHEET OF
DATE	FIGURE No. 1

MICROFILM DATE

DRAWING No.



0
10
20
30
40
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N
T252
W253
W 247
W249
P248
Refuse
partialy covered by
Fill
Muskeg
W250
Auto
Wrecker
W251
Road
W254
LEGEND:
○ T252 Testhole
● W253 Watertable well
● P248 Piezometer

Alberta ENVIRONMENT

SUBMITTED W. J. Gri
DATE Feb 14/86
APPROVED C. McCracken
DATE Feb 14/86

DESIGNED M.H.
CHECKED
DRAWN M.H.
CHECKED

Edson Sanitary Landfill

SITE PLAN

SCALE 1 = 2500
DATE
SHEET OF
FIGURE No. 2

FILE No.

TABLE 1: MONITORING WELL COMPLETION

Well Number	Date Installed	Well Depth (m)	Height of pipe above ground surface (m)	Screened interval (m)	Ground elevation (m)	Elevation of pipe (m)	Pipe diameter (m)
W247	29 5 85	6	.99	3 - 6	99.72	100.71	50
P248	29 5 85	5.5	1.02	4.5 - 5.5	99.23	100.25	50
W249	29 5 85	3	1.05	1 - 3	99.18	100.23	50
W250	29 5 85	3	1.05	1 - 3	-----	------	50
W251	29 5 85	4.5	1.14	1.5 - 4.5	-----	------	50
W253	29 5 85	3	.99	1.2 - 3	97.98	100.97	50
W254	29 5 85	3	1.00	1.5 - 3	-----	------	50

TABLE 2: WATER LEVEL DATA (July 19, 1985)

Well Number	Water Level Depth (b.g.l.) (m)	Elevation (m)
W247	1.51	98.21
P248	1.86	97.37
W249	1.79	97.39
W250	1.64	-----
W251	.92	-----
W253	.78	97.20
W254	1.72	-----

TABLE 3: CHEMICAL ANALYSES RESULTS (22 8 85)

	Well Numbers							
	247	248	249	250	251	253	254	C.D.W.S.# *
FIELD DATA								
Temp. (°C)	.65	.65	.85	4.0	1.2	.9	.6	
pH	7.8	8.3	7.7	7.6	7.4	8.2	7.9	
LAB DATA								
pH	7.2	7.3	7.3	6.9	7.2	6.4	7.3	
EC (mS/cm)	.62	6.2	9.8	3.1	1.2	.9	.5	
SAR	.33	.38	.74	.25	.50	.45	.11	
LAB ANALYSIS (all parameters in mg/L)								
Inorganic								
Ca	94	93	174	476	180	156	91	NE**
Mg	25.2	25.2	23.4	93.0	32.4	23.4	18.6	150
$CaCO_3$ (T.Hard)	340	337.5	465	1575	585	487.5	350	500
Na	13.9	16.2	37.0	23.1	27.7	23.1	4.2	300
K	2.35	2	2	3.1	4.3	2.4	1.2	NE
HCO_3	455	462	431	791	513	583	337	NE
$CaCO_3$ (T.Alk)	374	375	580	1316	687	560	277	500
SO_4	12	9.6	74.4	98.4	60	60	36	500
Cl	<1.77	<1.77	84.19	630.37	124	7.98	7.98	250
NO_3-N+NO_2-N	.14	.07	.14	.56	.28	.07	.14	10
NH_4-N	.35	.14	.14	.21	.14	.49	.14	.5
TDS	374	375	580	1316	687	560	326	1000
Orgnaic								
COD	6	6	26	93	50	60	2	
TOC	140.2	115.5	115.5	244.2	142.8	219.5	84.1	
TIC	2.2	3.4	6.7	8.3	14.5	16.6	6.6	
TC	142.4	118.9	122.2	252.5	157.3	236.1	90.7	
Metals								
Fe	.13	.03	.05	.07	.06	10.00	.04	.3
Mn	.45	.23	1.18	.32	.18	2.79	.01	.05
Cu	.01	<.01	.01	.01	.01	.01	.01	1.0
Zn	.01	.01	.01	.02	.01	.06	.01	5.0
Pb	.04	.05	.05	.11	.06	.02	.05	.05

* Canadian Drinking Water Standards

** Not Established

SOILS BRANCH DRILL HOLE LOG

Land Location LSD 16 Sec. 9 Tp. 53 R. 17 W 5

Date May 29, 1985 Supervisor M. deBrentani

Project Edson Municipal Landfill Investigation

Test Hole 247 to 251 inclusive.

Test Hole 247

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - 1	fill material	m
1 - 2	muskeg - peatmoss	s
2 - 6	sand, yellow brown, v. fine, high silt content	s

installation: water table well, 2" PVC, 6 m deep, slotted 3 - 6 m b.g.l.
4" auger, gravel pack, bent. seal.

Test Hole #248

0 - 1	fill material	m
1 - 2	sandy clay, yellow brown, soft	s
2 - 3	sand, brown, v. fine, high silt content	s
3 - 7	sand, greenish brown, v. fine, high silt content	s
7 - 8	clay, dk. grey, v. viscous, high silt content	s

installation: piezometer, 2" PVC, 5.5 m deep, screen 4.5 - 5.5 b.g.l.
7" auger, no gravel pack, bent. seal

Test Hole #249

Same as Test Hole #248

installation: Water table well, 2" PVC, 3 m deep, slotted 1 - 3 m b.g.l.
7" auger, gravel pack, bent. seal.

SOILS BRANCH DRILL HOLE LOG

Land Location LSD 15 Sec. 9 Tp. 53 R. 17 W. 5

Date May 29, 1985 Supervisor M. deBrentani

Project Edson Municipal Landfill Investigation

Test Hole 252 to 254 inclusive.

Test Hole 252

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - 1	fill material	m
1 - 4	muskeg - peatmoss	s
4 - 4.5	bentonite? v. light grey, soft	s
4.5 - 6	clay, grey, very soft plastic, high silt content	s

Installation: none - testhole

Test Hole #253

same as #252

Installation: Water table well, 2" PVC, 3 m deep,
slotted 1.2 - 3 m b.g.l., 7" auger,
gravel, bent. seal

Test Hole 254

0 - .5	top soil	m
.5 - 3	sand, yellow brown, v. fine, high silt content	s

Installation: Water table well, 3 m deep,
slotted 1.5 - 3 m b.g.l., 7" auger,
gravel pack, bent. seal.

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

#416

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole #250		
0 - .5	fill material	m
.5 - 2	sand, grey brown, fine	s
2 - 3	sand, brown, v. fine, thin layers of iron oxides and bentonite	s
Installation:	Water table well, 2" PVC, 3 m deep, slotted 1 - 3 m b.g.l. 7" auger, gravel pack, bent. seal.	
Test Hole #251		
0 - 0.5	fill material	m
0.5 - 4.5	sand, grey brown, v. fine, high silt content and clay layers	s
Installation:	Water table well, 2" PVC, 4.5 m deep, slotted 1.5 - 4.5 m b.g.l., 7" auger, gravel from 1 - 3.5 m b.g.l., bent. seal.	

FERINTOSH RECLAIMED LANDFILL

NW 3-44-21-W4

LOCATION AND SITE DESCRIPTION

- the site is located 800 m north of the Village's water treatment plant (Figure 1);
- the site has been reclaimed and is used as a campground;
- the land slopes toward Little Beaver Lake;
- primarily domestic refuse was disposed of at the site;
- the disposal site has an area of approximately 0.5 ac (0.2 ha).

FIELD PROGRAM

Test Drilling and Monitor Completion

- three testholes drilled (locations shown in Figure 2 and borehole logs attached);
- Two water table wells and a piezometer were installed.

Monitoring

- water levels recorded on September 5, 7 and 12, 1985 (Table 1);
- groundwater samples were collected for chemical analysis on September 12, 1985 (Table 2).

STUDY RESULTS

Geology

- clay till containing medium to fine grained sand lenses overlies shale and siltstone;
- surficial materials approximately 7 m thick.

Hydrogeology

- shallow groundwater flow is west towards Little Beaver Lake;
- the water table is approximately 2 m below ground surface in the landfill area;
- the water level in W477 had not reached equilibrium by 85/09/12;

- the hydraulic conductivity of sand and of till is 10^{-4} to 10^{-5} cm/s and 10^{-6} to 10^{-7} cm/s, respectively, based on visual grain size analysis.

Hydrochemistry

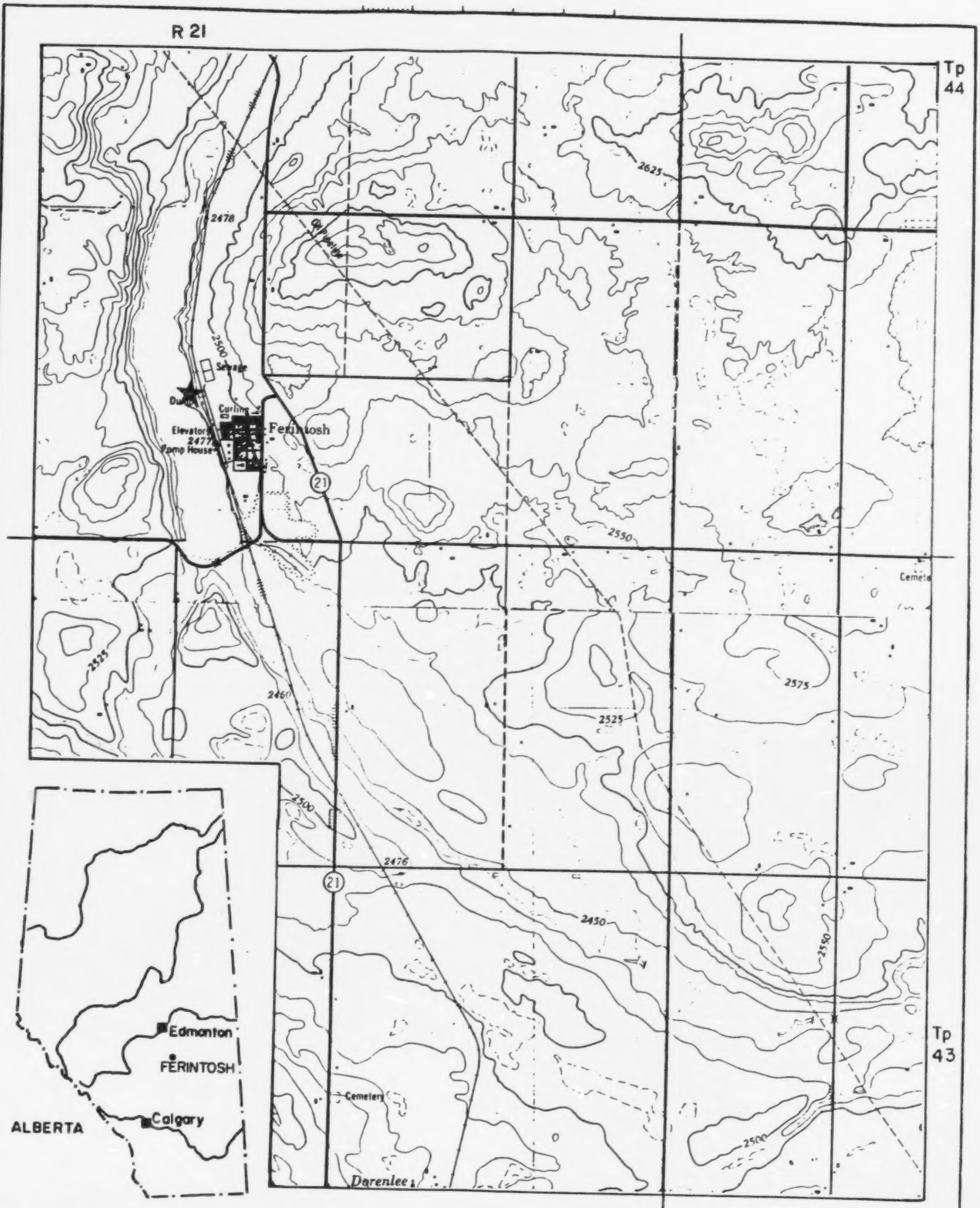
- groundwater from the bedrock is the Na/HCO_3 type with a total dissolved solids (TDS) concentration <500 mg/L;
- shallow groundwater is the $Ca\text{-}Mg/HCO_3$ type with TDS <1000 mg/L;
- groundwater from wells downgradient of the waste site (W476, W477) has elevated concentrations of chloride, nitrate, total hardness, and T.D.S.;
- slightly higher organic content in downgradient wells.

CONCLUSIONS AND RECOMMENDATIONS

- shallow groundwater has been contaminated. However, the level of contamination is very low. Only total hardness concentration in groundwater from W476 and W477, slightly exceeds Canadian Drinking Water Standards;
- due to low level of contamination and low hydraulic conductivity of surficial sediments (which will inhibit mobility of contaminants) monitoring will be discontinued;
- site should be downgraded to low priority.

MICROFILM DATE

DRAWING No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Tp 44
2625
2478
2500
Sewage
Dump
Curling
Elevators
2477
Pump House
Ferintosh
21
2550
Cemetery
2525
2460
2575
2525
2500
2476
21
2450
2550
Tp 43
Cemetery
2500
Darenlee
Edmonton
FERINTOSH
Calgary
ALBERTA

Alberta
ENVIRONMENT

SUBMITTED W. J. Lewis
DATE Feb 14/86
APPROVED J. McCracken
DATE Feb 14/86.

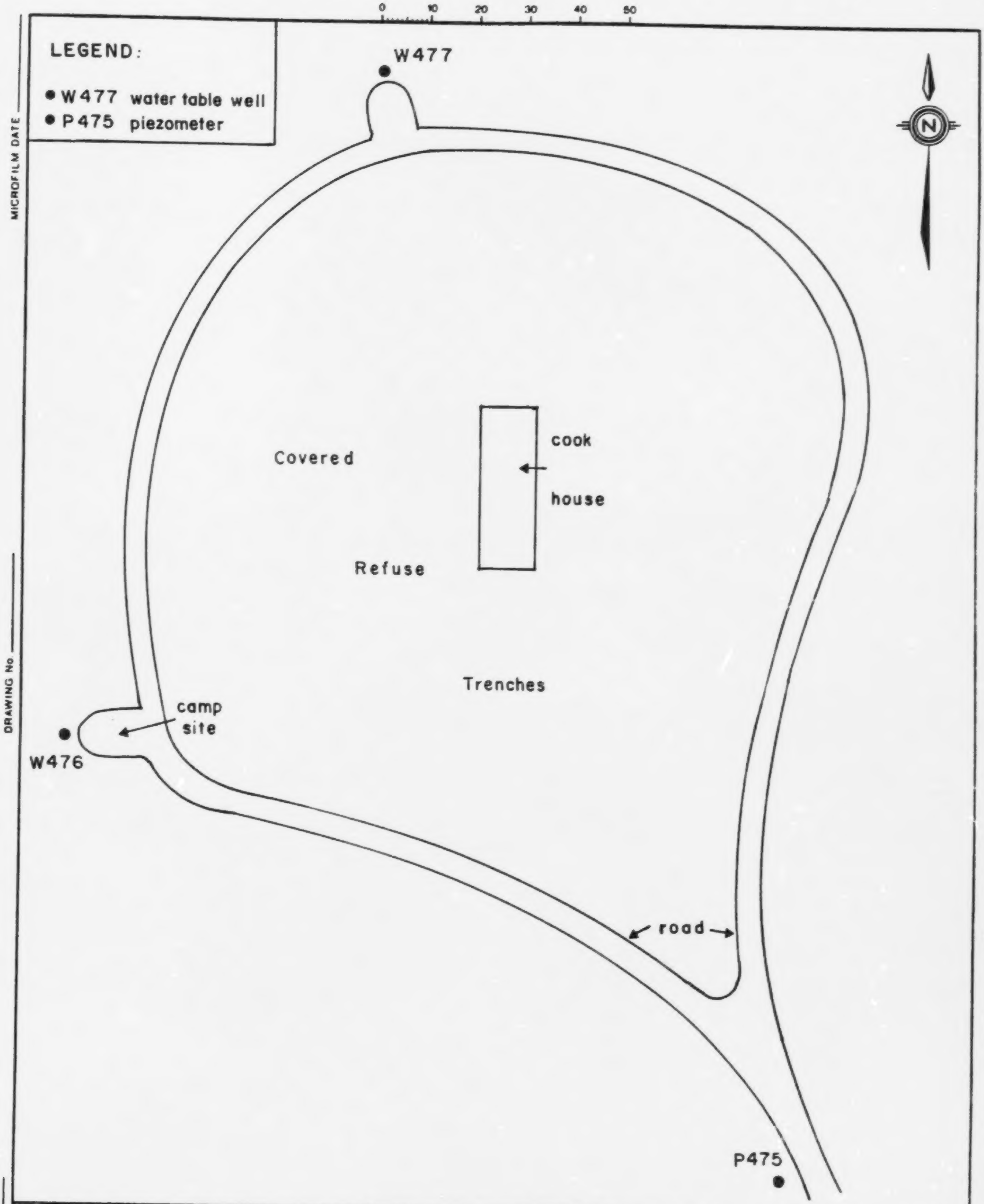
DESIGNED
CHECKED
DRAWN
CHECKED

FERINTOSH RECLAIMED LANDFILL

LOCATION PLAN

SCALE 1:50000
DATE
SHEET OF
FIGURE No. 1

FILE No.


0
10
20
30
40
50
LEGEND:
● W477 water table well
● P475 piezometer
W477
Covered
Refuse
Trenches
cook
house
camp
site
W476
road
P475
N

MICROFILM DATE

DRAWING No

FILE No.

Alberta
ENVIRONMENT

SUBMITTED W.J.
DATE Feb. 14/86
APPROVED
DATE Feb 14/86

DESIGNED WC
CHECKED
DRAWN MD
CHECKED

FERINTOSH RECLAIMED LANDFILL

SITE PLAN

not to scale

DATE

SHEET OF

FIGURE No. 2

TABLE 1: Water Level Data

Well Number	Water levels (below ground level) (m)		
	85/09/05	85/09/07	85/09/12
475	12.72	2.43	2.40
476	--	2.45	2.40
477	5.51	5.17	5.81

TABLE 2: Groundwater Chemistry Analyses

	Well Numbers			C.D.W.S.*
	P475	W476	W477	
LAB ANALYSIS - all parameters in mg/L				
Inorganic				
Ca	15	195	129	
Mg	1.8	47	47	150
K	1.1	6.3	2.7	
Na	152.5	72	79	300
Cl	1.78	45	18.6	250
SO_4	86	250	199	500
HCO_3	301	512	453	
NH_4-N	0.8	0.07	0.07	1
NO_3-N	0.21	3.45	0.63	10
Total Hard.	45	680	520	500
T.D.S.	402	933	749	1000
Metals				
Fe	[illegible]	0.02	0.04	0.3
Mn	0.01	0.04	0.03	0.05
Cu	<0.01	0.01	0.01	1.0
Zn	0.01	0.03	0.02	5.0
Pb	0.02	0.05	0.04	0.05
Organics				
TOC	4.6	7.9	13.6	
TIC	79.8	116	41	
TC	84.4	123.9	54.6	
COD	5	26	40	
Other				
pH	8.5	6.2	8.2	
EC (mS/cm)	0.63	1.42	1.11	
S.A.R.	9.8	1.2	1.5	

* Canadian Drinking Water Standards

SOILS BRANCH DRILL HOLE LOG

Land Location NW Sec. 3 Tp. 38 R. 27 W. 4

Date September 5, 1985 Supervisor W. Ceroici

Project Ferintosh Reclaimed Landfill

Test Hole 475 to 478 inclusive.

Test Hole 475

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - 1	topsoil, brown-black, humic	d
1 - 3	clay, brown, firm, iron oxide streaks	d
3 - 7.5	till, brown, firm, layers of greenish shale	sm
7.5 - 10.5	siltstone, grey, firm greensih shale interbeds	d
10.5 - 15	shale, grey brown	vm - s

Installation: piezometer, screened interval 10 - 15 m

Test Hole #476

0 - 2	fill	d
2 - 3.5	clay, brown	sm - m
3.5 - 6	sand, brown, fine grained	s

Installation: watertable well, 6 m deep, slotted 3 - 6 m b.g.l., 2" PVC pipe

Test Hole #477

0 - 1	topsoil, brown	d
1 - 3	sand, brown, medium to fine grained	d - sm
3 - 5	sand, brown, medium to fine grained, some coal	m
5 - 6	till, brown, sandy, sand layers	s

Installation: watertable well, 6 m deep, slotted 1.5 - 6 m b.g.l., 2" PVC pipe

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

Gleichen Landfill

Pt. S.W. 24-22-23-W4

LOCATION AND SITE DESCRIPTION

- the site, approximately 7 ac (3 ha) in area, is located 1 km northwest of the Town of Gleichen (Figure 1);
- site has recently been closed and is to be reclaimed.

FIELD PROGRAM

Test Drilling and Monitor Completion

- twenty-one test holes drilled (locations shown in Figure 2 and borehole logs attached);
- seven water table wells and fourteen piezometers installed (completion details in Table 1).

Monitoring

- water levels recorded five times since November 3, 1983 (Table 2);
- groundwater and reservoir samples collected for chemical analysis in August 1984.

STUDY RESULTS

Geology

- in the upper part of the landfill (northeastern portion), sand and sandy till overlies shale and sandstone;
- in the lower part of the landfill (northwest portion), shale and sandstone bedrock outcrops;
- bedrock is thin-bedded and appears to slope toward the west-northwest.

Hydrogeology

- shallow groundwater flow is west away from Gleichen reservoir (Figure 3);
- the depth to the water table varies from a maximum of 11 m in the upper part of the landfill to a minimum of 4 m in the lower part;

- hydraulic conductivity of the shale and sandstone is in the order of 10^{-4} to 10^{-3} cm/s.

Groundwater Chemistry

- groundwater is predominantly the sodium/sulphate type and is highly mineralized.
- the total hardness, sodium, sulphate and total dissolved solids (TDS) concentrations exceed the upper limits for Canadian Drinking Water;
- groundwater from wells 7049-H and 7050-H, located in the landfill area, and 7045-H, located down-gradient from the landfill area, have high TDS and chloride concentrations suggesting contamination from the refuse disposal operation;

Gleichen Reservoir Water Chemistry

- reservoir water is the calcium-magnesium/bicarbonate type with all chemical constituents substantially below recommended upper limits for Canadian drinking water;
- the reservoir water is fresher than the shallow groundwater which corroborates that the reservoir is a recharge feature.

CONCLUSION

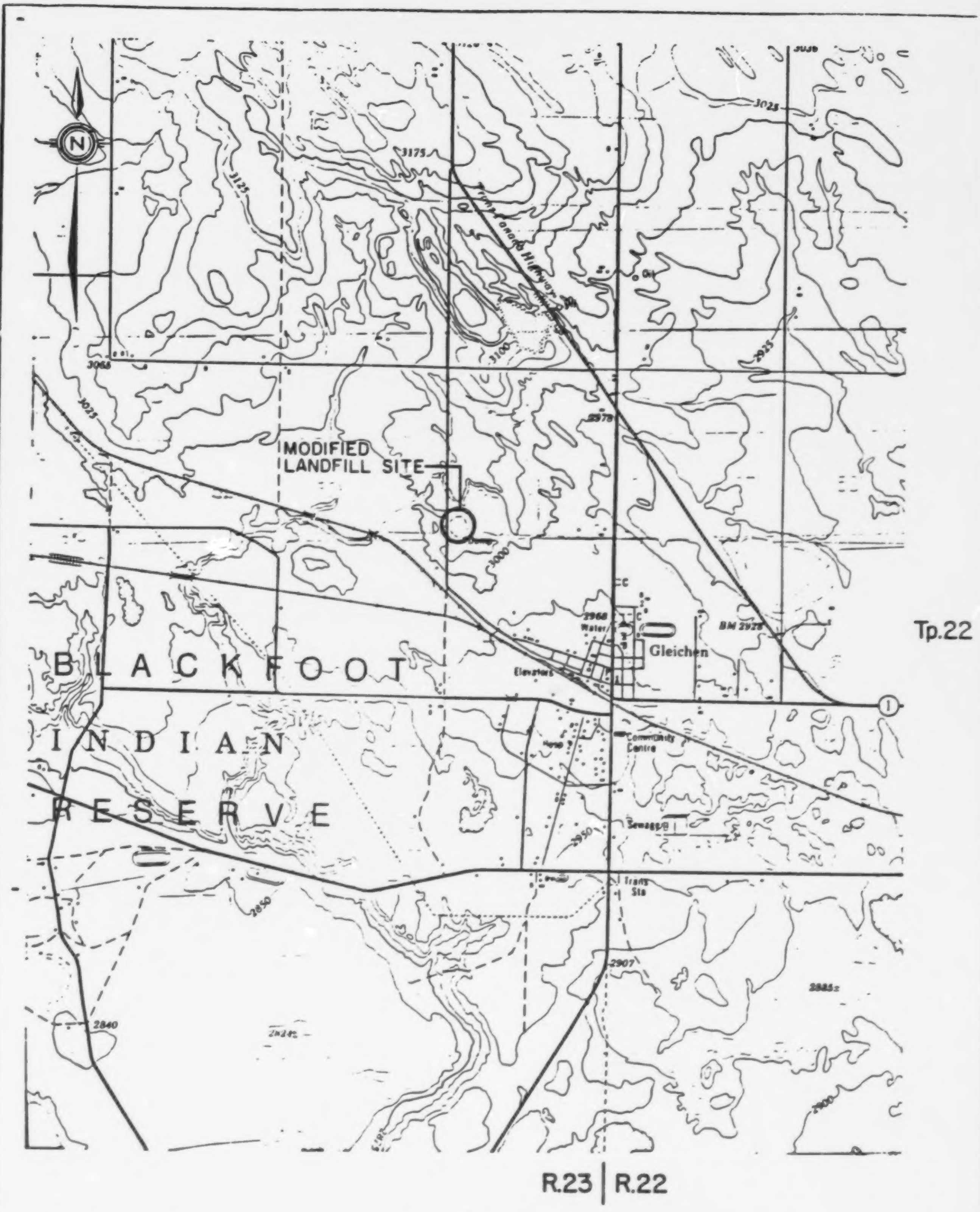
- groundwater down-gradient from the landfill is highly mineralized and appears to be contaminated with inorganic compounds originating from the disposal operation;
- the reservoir water level is above the water table suggesting that the reservoir recharges the groundwater system;
- shallow groundwater flows to the east from the landfill, away from the reservoir.

RECOMMENDATIONS

- the water level in the reservoir should be maintained as close to full supply level as possible to prevent poor quality groundwater from contaminating reservoir water.
- reservoir water samples should be collected for chemical analysis on a regular basis (4 times per year);

MICROFILM DATE

DRAWING No.



N
3175
3125
3100
3065
3025
3025
2975
2925
3000
Trans Canada Highway
MODIFIED LANDFILL SITE
BLACKFOOT
INDIAN
RESERVE
2960
Water
Elevators
Gleichen
BM 2925
Tp.22
1
Hosp
Community Centre
CP
Sewage
2950
Trans Stn
2850
2907
2840
2824±
2885±
2900
R.23
R.22

Alberta
ENVIRONMENT

GLEICHEN MODIFIED LANDFILL SITE

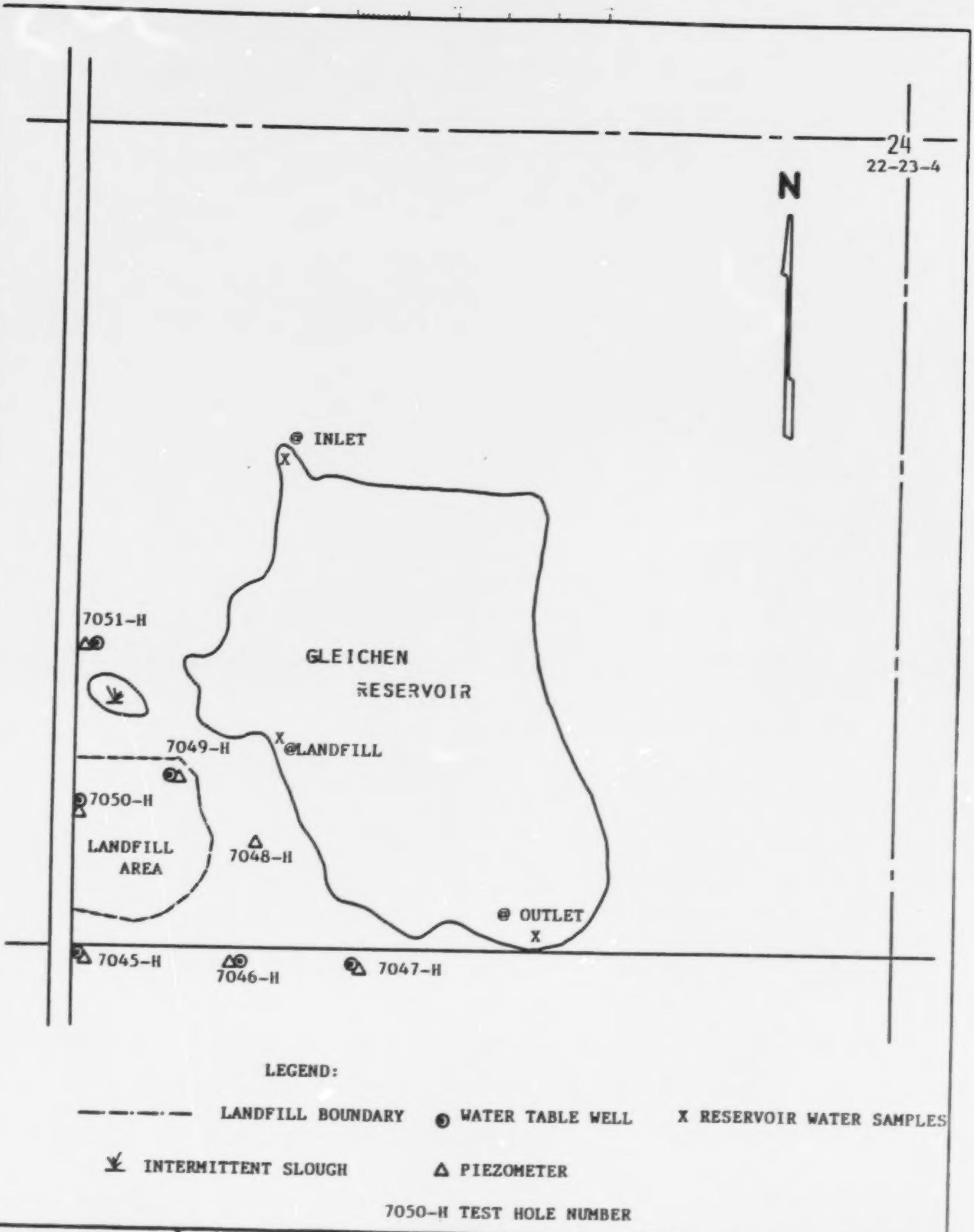
GLEICHEN AREA - COUNTY # 16
S.W. 1/4 24-22-23-W4
STUDY AREA

FILE No.

SUBMITTED	INVESTIGATED R.M. COUPLAND	SCALE 1:50 000	FIG. No. 1
DATE Feb 14/86	CHECKED	DATE MAY 1984	DWG. No. C16-Z-1-E-2, 9220
APPROVED	DRAWN B.A. BAKER		
DATE Feb 14/86	TRACED		

MICROFILM DATE

DRAWING No


24
22-23-4
N
@ INLET
X
GLEICHEN
RESERVOIR
7051-H
7049-H
X
@LANDFILL
7050-H
LANDFILL
AREA
7048-H
@ OUTLET
X
7045-H
7046-H
7047-H
LEGEND:
LANDFILL BOUNDARY
WATER TABLE WELL
X RESERVOIR WATER SAMPLES
INTERMITTENT SLOUGH
PIEZOMETER
7050-H TEST HOLE NUMBER

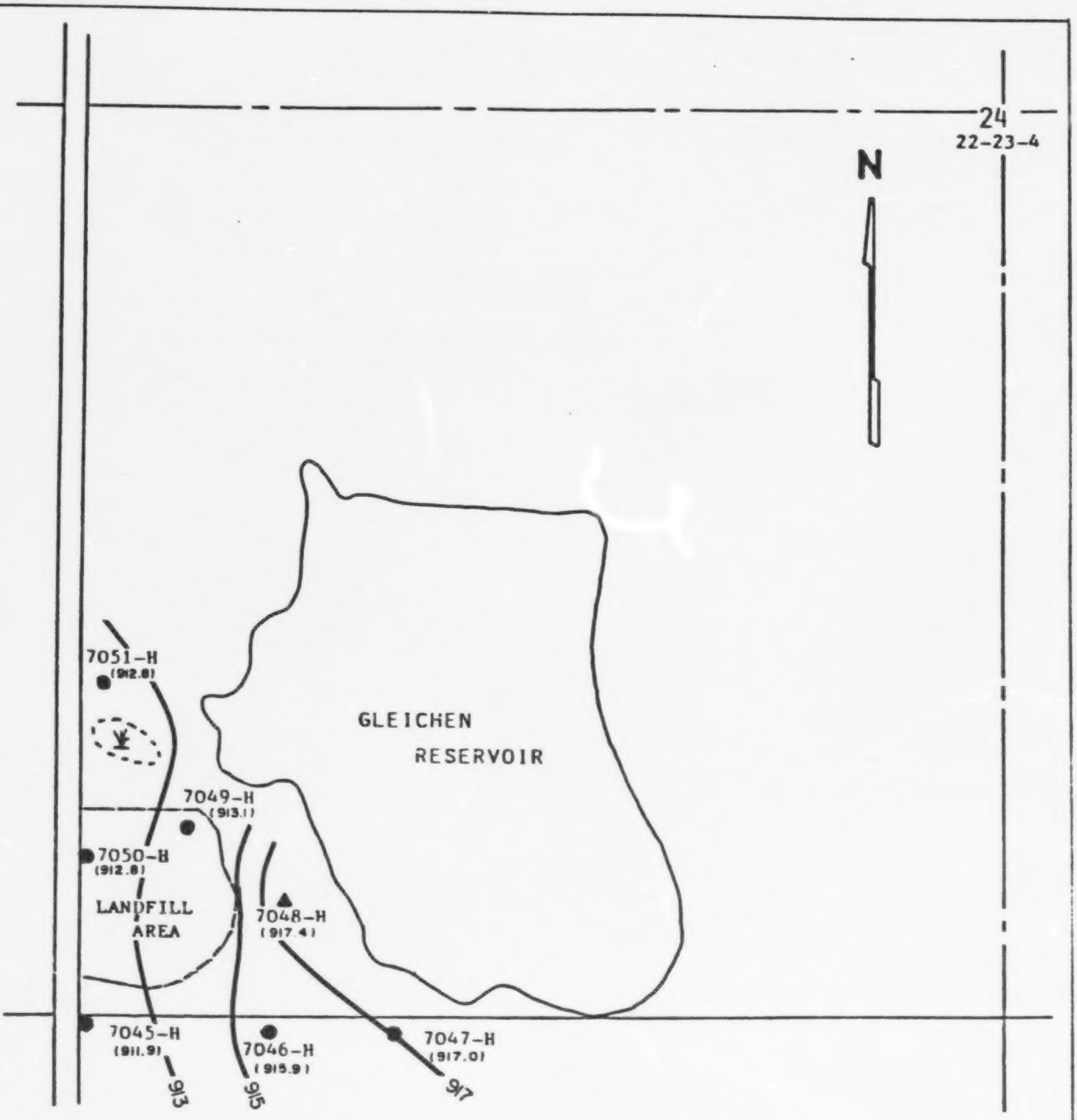
Alberta ENVIRONMENT

SUBMITTED	
DATE Feb 14/86	
DESIGNED RMC	CHECKED
APPROVED J. McGregor	
DATE Feb. 14/86	
DRAWN	CHECKED

GLEICHEN MODIFIED LANDFILL SITE
GLEICHEN AREA - COUNTY #16
S.W.¼ 24-22-23-W4
LOCATION PLAN

SCALE 1:5000	FIG. No. 2
DATE SEPT. 1984	DWG. No. C16-Z-1-E-2, 9223

FILE No



24
22-23-4
N
7051-H
(912.8)
GLEICHEN
RESERVOIR
7049-H
(913.1)
7050-H
(912.8)
LANDFILL
AREA
7048-H
(917.4)
7045-H
(911.9)
7046-H
(915.9)
7047-H
(917.0)
913
915
917

LEGEND:

—·—·— LANDFILL BOUNDARY ● WATER TABLE WELL

——915 WATER TABLE CONTOUR ▲ PIEZOMETER

INTERMITTEN SLOUGH

7050-H TEST HOLE NUMBER
(917.0) GROUNDWATER ELEVATION (m)

Alberta
ENVIRONMENT

SUBMITTED ....
DATE Feb. 14/86
APPROVED B. McCracken
DATE Feb. 14/86

DESIGNED RMC
CHECKED
DRAWN
CHECKED

GLEICHEN MODIFIED LANDFILL SITE
GLEICHEN AREA - COUNTY #16
S.W.¼ 24-22-23-W4

WATER TABLE CONTOURS 1984-08-07

SCALE 1:5000
FIG. No. 3
DATE SEPT. 1984
DWG. No. C16-Z-1-E-2, 9225

TABLE 1

GLEICHEN LANDFILL INVESTIGATION

Pt. S.W. 24-22-23-4

MONITORING WELL COMPLETION INFORMATION

Observation Well #	Type of Observation Well	Date Installed	Observation Well Depth (m)	Height of Pipe Above Ground Surface (m)	Screened Interval (m)	Ground Elevation (m)	Elevation Top of Pipe (m)
7045-H	WTW	84/08/07	22.98	0.57	6.10-22.98	923,38	923.95
	PIEZ	83/11/01	17.08	0.56	16.08-17.08	923.37	923.93
7046-H	WTW	84/08/07	17.00	0.51	6.10-17.00	924.93	925.44
	WTW	83/11/02	4.77	0.50	1.50- 4.77	924.93	925.40
	PIEZ	83/11/02	9.10	0.59	8.35- 9.10	924.94	925.53
	PIEZ	83/11/02	13.03	0.57	12.03-13.03	924.94	925.51
7047-H	WTW	84/08/07	14.04	0.54	6.10-14.04	924.93	925.47
	PIEZ	83/11/02	15.68	0.47	15.18-15.68	924.89	925.36
	PIEZ	83/11/02	11.17	0.47	10.58-11.17	924.89	925.36
7048-H	PIEZ	83/11/02	18.04	0.66	17.04-18.04	927.11	927.77
	PIEZ	83/11/02	15.23	0.60	14.72-15.23	927.11	827.71
7049-H	WTW	84/08/07	8.12	0.48	1.50- 8.12	917.81	918.29
	PIEZ	83/11/02	7.07	0.33	6.56- 7.07	918.08	918.41
	PIEZ	83/11/02	5.20	0.28	4.69- 5.20	918.08	918.36
7050-H	WTW	84/08/07	6.66	0.56	1.50- 6.66	916.64	917.20
	PIEZ	83/11/03	6.56	0.54	6.06- 6.56	916.83	917.37
	PIEZ	83/11/03	5.12	0.51	4.62- 5.12	916.83	917.34
	PIEZ	83/11/03	2.38	0.46	1.88- 2.38	916.83	917.29
7051-H	WTW	84/08/07	8.22	0.55	1.50- 8.22	917.23	917.78
	PIEZ	83/11/03	12.67	0.53	12.42-12.67	917.18	917.71
	PIEZ	83/11/03	5.03	0.54	4.36- 5.03	917.18	917.72

TABLE 2

GLEICHEN LANDFILL INVESTIGATION

Pt. S.W. 24-22-23-4

GROUNDWATER ELEVATIONS (Geodetic Metric)

Well Number	Depth (m)	Monitor Ground Elev. (m)	1983-11-03		1984-01-04		1984-05-08		1984-08-07		1984-08-13	
			Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.
W7045-H	22.98	923.38							11.46	911.92	11.48	911.90
P7045-H	17.08	923.37	11.27	912.10	11.32	912.05	11.54	911.83	11.43	911.94	11.44	911.93
W7046-H	17.00	924.93							9.07	915.86	6.97	917.96
W7046-H	4.77	924.93	Dry	<920.13	Dry	-	Dry	-	Dry	-	Dry	-
P7046-H	9.10	924.94	Dry	<915.84	Dry	-	Trace	915.84	Dry	-	Dry	-
P7046-H	13.08	924.94	9.61	915.33	9.77	915.17	10.22	914.72	9.37	915.57	9.32	915.62
W7047-H	14.04	924.93							7.97	916.96	7.96	916.97
P7047-H	15.68	924.89	8.28	916.61	8.55	916.34	9.05	915.84	8.15	916.74	8.08	916.81
P7047-H	11.17	924.89	8.16	916.73	8.41	916.48	8.90	915.99	7.80	917.09	7.93	916.96
P7048-H	18.04	927.11	9.87	917.24	10.14	916.97	10.65	916.46	9.71	917.40	9.66	917.45
P7048-H	15.28	927.11	9.87	917.24	10.11	917.00	10.59	916.52	9.66	917.45	9.60	917.51
W7049-H	8.12	917.81							4.63	913.14	4.65	913.16
P7049-H	7.07	918.08	4.91	913.17	5.01	913.07	5.23	912.85	4.90	913.18	4.92	913.16
P7049-H	5.20	918.08	4.41	913.67	4.56	913.52	4.84	913.24	4.73	913.35	4.74	913.34
W7050-H	6.66	916.64							3.86	912.79	3.83	912.82
P7050-H	6.56	916.83	4.05	912.78	4.12	912.71	4.29	912.54	4.03	912.80	4.01	912.82
P7050-H	5.12	916.83	4.04	912.79	4.12	912.71	4.28	912.55	4.03	912.80	4.00	912.83
P7050-H	2.38	916.83	Dry	<914.45	Dry	-	Dry	-	Trace	914.45	Dry	-
W7051-H	8.22	917.23							4.41	912.82	4.38	912.85
P7051-H	12.67	917.18	4.73	912.45	4.03	913.15	4.18	913.00	4.35	912.83	4.32	912.86
P7051-H	5.03	917.18	4.40	912.78	4.47	912.71	4.65	912.53	4.37	912.81	4.34	912.84

TABLE 3

GLEICHEN LANDFILL CONTAMINATION INVESTIGATION

Pt. S.W. 24-22-23-4

GROUNDWATER CHEMISTRY ANALYSES

Well Number	7045-H	7046-H	7047-H	7047-H	7048-H	7048-H	7049-H	7049-H
Type*(Depth, m)	P(17.08)	P(13.03)	P(11.17)	P(15.68)	P(18.04)	P(15.23)	P(5.20)	P(7.07)
Lab Data								
pH	7.5	7.2	6.1	7.7	7.3	5.8	6.1	6.5
EC (mS/cm)	12.81	8.24	6.94	9.04	5.58	9.29	12.35	10.91
SAR	34.6	16.4	18.6	18.0	9.5	28.6	37.0	30.9
LAB ANALYSIS								
Inorganic (mg/L)								
Hardness	1600.	1785.	1120.	1995.	1690.	1220.	1275.	1360.
Ca	368.	370.	294.	394.	398.	320.	376.	340.
Mg	165.24	208.98	93.56	245.43	168.88	102.06	81.40	123.93
Na	3187.8	1598.5	1428.3	1846.9	894.7	2300.0	3036.0	2622.0
HCO_3	771.65	311.71	52.46	592.31	544.12	70.15	75.03	334.28
Cl	53.18	6.20	5.32	9.75	7.80	7.80	15.60	10.64
SO_4	7584.0	4742.4	4032.0	5280.0	3024.0	6096.0	7392.0	6768.0
K	16.81	18.77	10.56	14.08	11.73	15.25	16.81	16.81
NO_3-N	<0.05	<0.05	1.85	0.95	0.05	0.10	108.40	7.05
TDS (mg/L)	11,800	7120.	5870.	8090.	4780.	8890.	11,400.	10,100.
Metals (mg/L)								
FE	0.99	5.20	0.64	0.65	0.39	0.46	0.22	0.22
Mn	7.60	6.90	4.30	13.80	4.74	3.12	1.66	3.20
Cu	0.02	0.02	0.03	0.02	0.02	0.03	0.03	0.03
Zn	0.14	0.29	0.17	0.10	0.02	0.14	0.12	0.16
Pb	0.17	0.14	0.16	0.16	0.12	0.16	0.16	0.19
Organic (mg/L)								
COD	57.0	57.0	48.0	130.0	26.5	26.5	26.5	13.3
TOC	20.0	10.0	9.0	48.0	10.0	9.0	3.0	3.0
TIC	160.0	87.0	45.0	110.0	104.0	41.0	41.0	77.0
TC	180.0	97.0	54.0	158.0	114.0	50.0	44.0	80.0

* P - Piezometer

TABLE 3 (cont.)

GLEICHEN LANDFILL CONTAMINATION INVESTIGATION

Pt. S.W. 24-22-23-4

GROUNDWATER CHEMISTRY ANALYSES

Well Number	7050-H	7050-H	7051-H	7051-H	Reservoir	Reservoir	Reservoir	CDWS[1]
Type*(Depth,m)	P(5.12)	P(6.56)	P(5.03)	P(12.67)	@ inlet	@ landfill	@ outlet	
Lab Data								
pH	5.4	5.6	5.1	7.4	8.3	9.0	8.9	
EC (mS/cm)	9.40	9.67	12.38	9.74	0.19	0.22	0.22	
SAR	24.9	25.8	32.7	30.4	<0.1	1.0	1.0	
LAB ANALYSIS								
Inorganic (mg/L)								
Hardness	1360.	1360.	1605.	1130.	137.5	102.5	102.5	500
Ca	348.	338.	342.	286.	33.	19.	18.	NE[2]
Mg	118.5	125.1	182.2	100.2	13.4	13.4	14.0	150
Na	2106.8	2189.6	3013.0	2346.0	2.3	23.0	23.0	300
CO_3	-	-	-	-	5.1	11.1	8.1	NE
HCO_3	39.65	75.64	21.96	1097.39	120.17	81.13	87.23	NE
Cl	8.86	7.80	8.86	<0.71	1.77	5.32	6.20	250
SO_4	5856.0	6000.0	8016.0	5376.0	33.6	52.8	55.2	500
K	14.86	13.29	16.42	13.29	0.39	0.39	1.17	NE
NO_3-N	0.60	0.10	6.45	0.50	<0.07	<0.07	<0.07	10
TDS (mg/L)	8490.	8730.	11,600.	8670.	148.6	164.9	168.6	1000
Metals (mg/L)								
Fe	4.58	0.09	0.67	0.48	-	-	-	0.3
Mn	3.98	4.12	7.72	3.68	-	-	-	0.05
Cu	0.03	0.04	0.03	0.03	-	-	-	1.0
Zn	0.25	0.08	0.38	0.06	-	-	-	5.0
Pb	0.18	0.17	0.21	0.17	-	-	-	0.05
Organic (mg/L)								
COD	48.6	26.5	17.7	345.0	-	-	-	
TOC	12.	4.	1.	98.	-	-	-	
TIC	32.	92.	76.	220.0	-	-	-	
TC	44.	96.	77.	318.	-	-	-	

[1] CDWS Canadian Drinking Water Standards

[2] NE Not Established

SOILS BRANCH DRILL HOLE LOG

Land Location SW Sec. 24 Tp. 22 R. 23 W 4

Date November 1983 Supervisor R. M. Coupland

Project Gleichen Landfill Investigation

Test Hole 7045-H to 7051-H inclusive.

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole 7045-H		
0- 0.25	fine sand and silt, grass roots	d
0.25- 0.75	very fine sand and silt, flour	d
0.75- 1.0	silt and sand, flour	d
1.0 - 1.5	silt and very fine sand, flour	d
1.5 - 1.75	very fine sand and silt, flour	d
1.75- 2.25	fine sand and silt	d
2.25- 2.5	clay, sandy	d
2.5 - 3.0	till, sandy clay	sm
3.0 - 3.5	till, sandy clay, sand lenses	sm
3.5 - 4.5	sandy shale, unconsolidated, soft weathered	sm - m
4.5 - 5.25	sandy shale, sandstone fragments	sm - m
5.25-11.0	sandstone, soft weathered, olive/ beige	sm - m
11.0 -14.25	sandy shale, light brown	sm - m
14.25-15.5	sandy shale, grey brown	sm - m
15.5 -17.0	sandstone, water entering, grey	vm - s

*Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole 7046-H		
0- 0.25	sand and silt, grass roots	d
0.25- 0.5	silt and fine sand, flour	d
0.5 - 1.0	clay, sandy	d
1.0 - 1.5	till, sandy clay	d - sm
1.5 - 2.25	till, sandy clay, soft weathered shale and sandstone fragments, dark brown	d - sm
2.25- 4.25	sandy shale, soft weathered, brown	sm
4.25- 4.75	sandy shale, dark brown/black	sm
4.75- 5.5	sandstone, yellow/beige	sm
5.5 - 8.0	sandstone, olive/beige	sm - m
8.0 -10.75	sandstone, yellow/beige	sm - m
10.75-11.25	sandstone, beige	sm - m
11.25-12.25	sandy shale, grey/brown	sm - m
12.25-13.25	shale, carbonaceous, black	m - vm
Test Hole 7047-H		
0- 0.25	sand and silt, blow dirt and grass roots	d
0.25- 0.5	fine sand and silt, flour	d
0.5 - 0.75	silt and very fine sand, flour	d
0.75- 1.0	silt and fine sand	d
1.0 - 1.5	till, clay, sandy	d - sm

Continued.....

*Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole 7047-H (Cont'd)		
1.5 - 4.25	till, sandy clay, dark brown	sm - m
4.25- 4.5	till, clay, shale fragments, soft	sm - m
4.5 - 4.75	shale, soft weathered, brown/black	sm - m
4.75- 6.0	siltstone, pale beige	sm - m
6.0 - 9.5	sandstone, yellow/olive	sm - m
9.5 -10.75	sandy shale, yellow/olive	m
10.75-11.25	sandstone, yellow/brown	vm - s
11.25-13.75	sandstone, yellow/brown	vm
13.75-15.75	shale, harder, grey black	m
Test Hole 7048-H		
0- 0.5	till, clay, sandy	d
0.5 - 0.75	silty clay, sandy	d
0.75- 1.0	till, sandy clay	d
1.0 - 1.5	till, sandy clay, sandy shale fragments	d
1.5 - 2.5	shale, carbonaceous, soft weathered, black	d
2.5 - 3.25	sandy shale, soft weathered, grey black	d
3.25- 3.75	shale, carbonaceous, soft weathered, black	d
3.75- 6.25	sandy shale, soft weathered, grey black	d
6.25- 7.0	shale, carbonaceous, soft weathered, black	d - sm

Continued.....

*Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole 7048-H (Cont'd)		
7.0 - 7.25	sandy shale, soft weathered, black	d - sm
7.25-10.0	siltstone, soft weathered, olive	d - sm
10.0 -12.5	siltstone, soft weathered, yellow/olive	d - sm
12.5 -14.25	sandy shale, soft weathered, yellow/beige	d - sm
14.25-15.0	shale, carbonaceous, soft weathered, dark brown/black	d - sm
15.0 -16.5	sandy shale, soft weathered, olive	sm - m
16.5 -18.25	sandstone, very soft, beige	m - vm
Test Hole 7049-H		
0- 0.25	sandstone, bentonitic, olive	d
0.25- 1.0	sandstone, fine-grained, bentonitic, olive	d - sm
1.0 - 1.5	sandstone, fine-grained, bentonitic, yellow/olive	sm
1.5 - 3.0	sandstone, fine-grained, bentonitic, yellow/olive	sm - m
3.0 - 3.75	sandstone, yellow/brown	sm - m
3.75- 4.0	sandy shale, yellow/brown	sm - m
4.0 - 4.5	shale, carbonaceous, dark brown	sm - m
4.5 - 5.25	shale, carbonaceous, grey brown	m

Continued.....

*Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole 7049-H (Cont'd)		
5.25- 6.25	sandy shale, grey brown	m
6.25- 6.75	sandy shale, olive grey	m - vm
Test Hole 7050-H		
0- 0.25	sand and silt	d
0.25- 0.5	clay, sandy	d
0.5 - 0.75	sandy clay	d
0.75- 1.0	sandy shale, yellow/olive	d - sm
1.0 - 2.75	sandstone, very soft, weathered, olive	m - vm
2.75- 3.25	sandy shale, weathered, yellow/beige	m
3.25- 4.0	shale, weathered, light brown	m
4.0 - 4.75	shale, carbonaceous, weathered, brown/black	m
4.75- 6.0	sandstone, weathered, olive beige	m
6.0 - 6.5	sandy shale, harder, olive grey	m

*Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole 7051-H		
0- 0.25	till, clay, sandy	d
0.25- 1.0	sandstone, yellow/beige	d - sm
1.0 - 2.0	sandstone, yellow/beige	sm
2.0 - 2.5	shale, carbonaceous, dark brown/ black	sm - m
2.5 - 3.5	sandy shale, olive/light brown	sm - m
3.5 - 4.25	sandstone, olive/light brown	sm - m
4.25- 5.0	shale, carbonaceous, brown/black	m - vm
5.0 - 5.5	sandy shale, light brown/yellow	m - vm
5.5 - 6.0	sandstone, soft, beige	m
6.0 - 6.5	sandstone, harder, olive/grey	sm
6.5 - 7.0	sandy shale, brown	m
7.0 - 9.5	sandstone, olive/grey	sm - m
9.5 - 9.75	sandstone, very hard, olive/grey	sm
9.75-12.25	sandstone, soft, olive-grey	m - vm
12.25-12.75	sandstone, hard, olive/grey	m

*Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

Glenwood Landfill

Pt. N.E. 36-4-27-W4 and Pt. S.E. 1-5-27-W4

LOCATION AND SITE DESCRIPTION

- the site is located about 1 km south of the Village of Glenwood (Figure 1);
- site is about 1 ac (0.3 ha) in size;
- approximately 0.8 ac (0.25 ha) has been reclaimed, while 0.2 ac (0.05 ha) remains as an active landfill.

FIELD PROGRAM

Test Drilling and Monitor Completion

- five test holes drilled (locations shown in Figure 2 and borehole logs attached);
- five water table wells installed (completion details in Table 1);

Monitoring

- water levels recorded on five occasions commencing August 29, 1984 (Table 2);
- groundwater and river samples collected for chemical analysis on September 7, 1984 (Table 3, Figure 3).

STUDY RESULTS

Geology

- in the vicinity of the landfill, clay till was encountered to depths in excess of 22 m (Test hole 3660-T);
- at the base of the reclaimed landfill area, alluvial deposits of sand and gravel overlie clay till (Test hole 3665-T).

Hydrogeology

- shallow groundwater flow is south toward the Belly River;
- the depth to the water table near the existing landfill varies from 1 to 6 m below ground surface, while below the reclaimed landfill, the water table occurs at a depth of 3 m below ground surface.
- the site is located in a groundwater recharge area;
- the clay till is expected to have a low permeability.

Groundwater Chemistry

- samples were collected from the five wells, the landfill trench and the Belly River. Sampling locations are shown in Figure 3;
- water samples can be categorized into three distinct chemical types; 1) calcium - magnesium/bicarbonate, 2) sodium bicarbonate and 3) calcium - magnesium sulphate;
- the calcium - magnesium/bicarbonate water from the Belly River and groundwater from 3655-T and 6078-H has a total dissolved solid (TDS) concentration of 175, 408 and 1053 mg/L respectively;
- the sodium/bicarbonate water obtained from the landfill trench has a TDS concentration in the order of 5000 mg/L with high concentrations of bicarbonate, chloride, potassium, iron and a high chemical oxygen demand (COD);
- the calcium - magnesium/sulphate groundwater from 3660-T and 3664-T have TDS concentrations ranging from 3500 to 8500 mg/L with hardness, magnesium, sodium, sulphate and manganese concentrations commonly exceeding upper limits for Canadian Drinking Water;
- slightly elevated concentrations of chloride, iron, manganese and COD in the wells down-gradient from the landfill indicate that shallow groundwater in the vicinity of the landfill may be contaminated;
- groundwater quality improves with depth (3660-T (22.45 m)).

CONCLUSIONS

- groundwater immediately down-gradient from the landfill is contaminated;
- low permeability clay till is effective in attenuating contaminants;
- the Belly River water has not been contaminated;
- inorganic constituents in water from the river do not exceed upper limits for Canadian Drinking Water Standards.

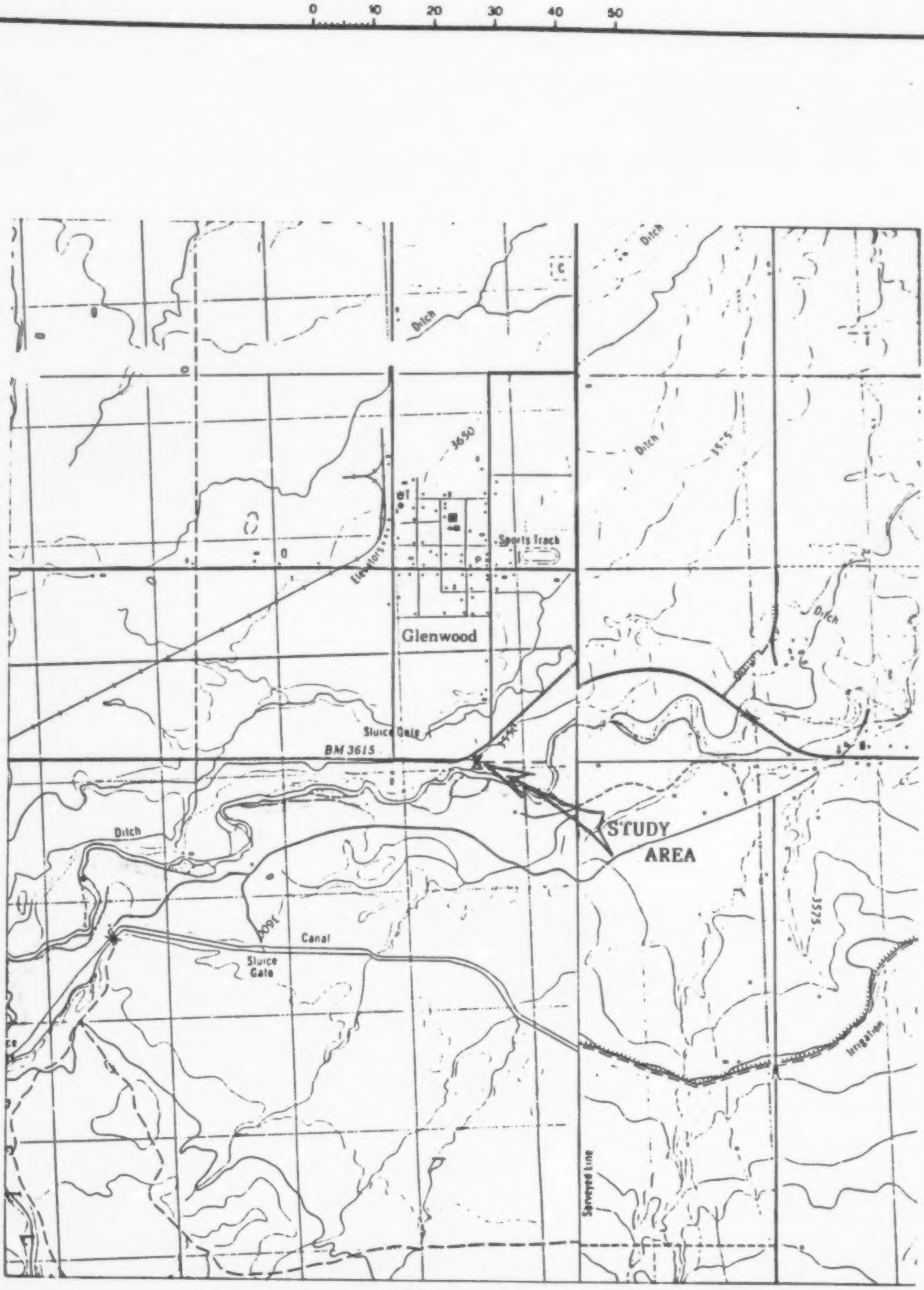
RECOMMENDATIONS

- no remedial action is necessary since river water is not being contaminated;
- liquid wastes should not be disposed of at this landfill and surface runoff should not be allowed to enter the landfill trench;

- additional groundwater instrumentation will be installed at the site for the purpose of collecting additional groundwater samples to establish the extent of shallow groundwater contamination.

MICROFILM DATE

DRAWING No


0
10
20
30
40
50
Ditch
C
Ditch
3650
Ditch
3575
Sports Track
Elevators
Ditch
Glenwood
Sluice Gate
BM 3615
STUDY AREA
Ditch
3600
Canal
Sluice Gate
3575
Irrigation
Surveyed Line

Alberta ENVIRONMENT

SUBMITTED
DATE Feb 14/86

APPROVED
DATE Feb. 14. 86

DESIGNED R.M.C.
CHECKED

DRAWN
CHECKED

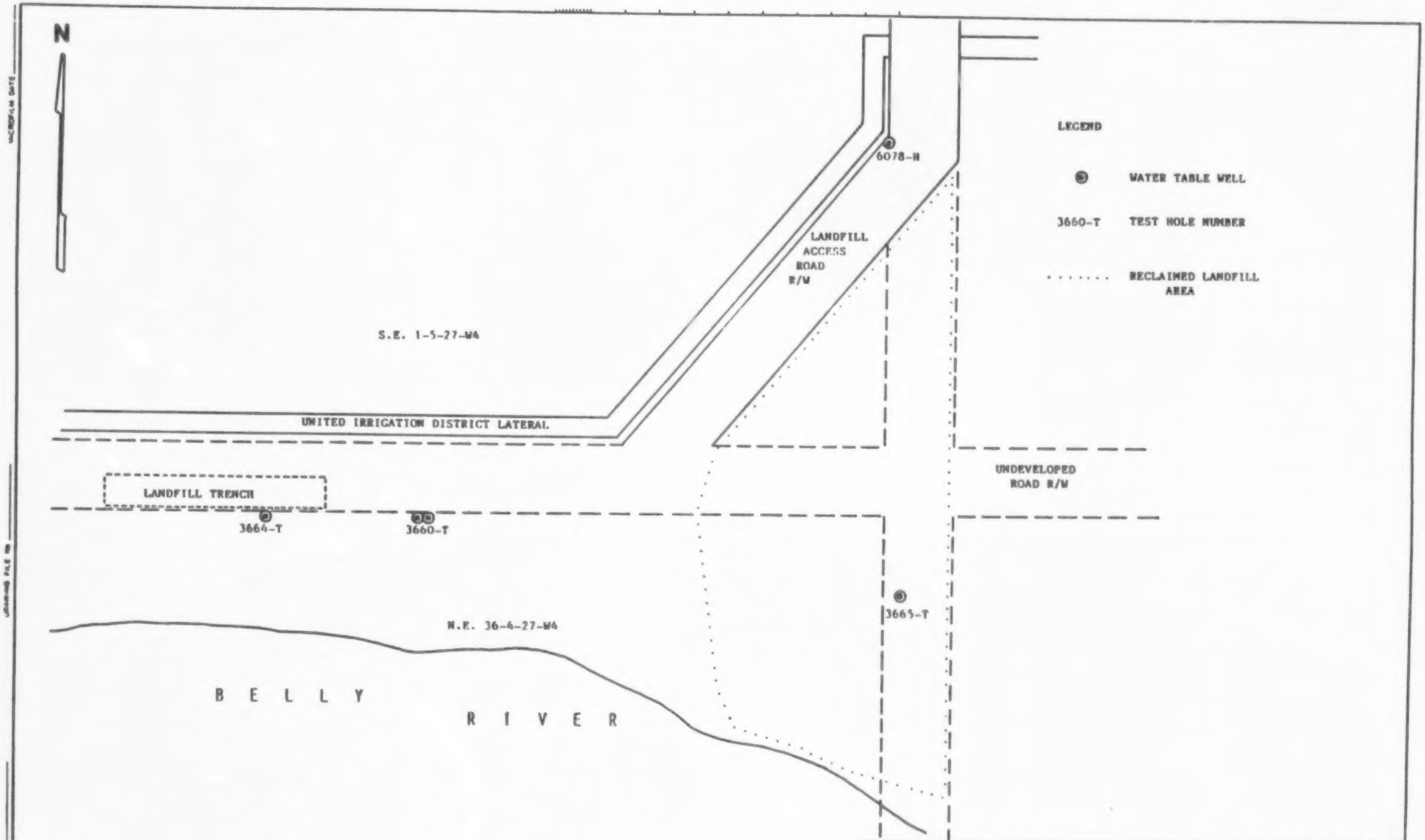
GROUNDWATER CONTAMINATION INVESTIGATION

GLENWOOD AREA - MUNICIPAL DISTRICT #6
Pt. N.E. 36-4-27-W4 & Pt. S.E. 1-5-27-W4
STUDY AREA

SCALE 1:50,000
DATE NOVEMBER 1984

SHEET 1 OF 1
FIGURE No. 1

FILE No


N
LEGEND
WATER TABLE WELL
3660-T TEST HOLE NUMBER
RECLAIMED LANDFILL AREA
6078-H
LANDFILL ACCESS ROAD R/W
S.E. 1-5-27-W4
UNITED IRRIGATION DISTRICT LATERAL
UNDEVELOPED ROAD R/W
LANDFILL TRENCH
3664-T
3660-T
3665-T
N.E. 36-4-27-W4
BELLY RIVER

Alberta ENVIRONMENT

SUBMITTED W.J. [illegible]	DESIGNED RMC
DATE Feb 14 85	CHECKED
APPROVED [illegible]	DRAWN
DATE Feb 14 85	CHECKED

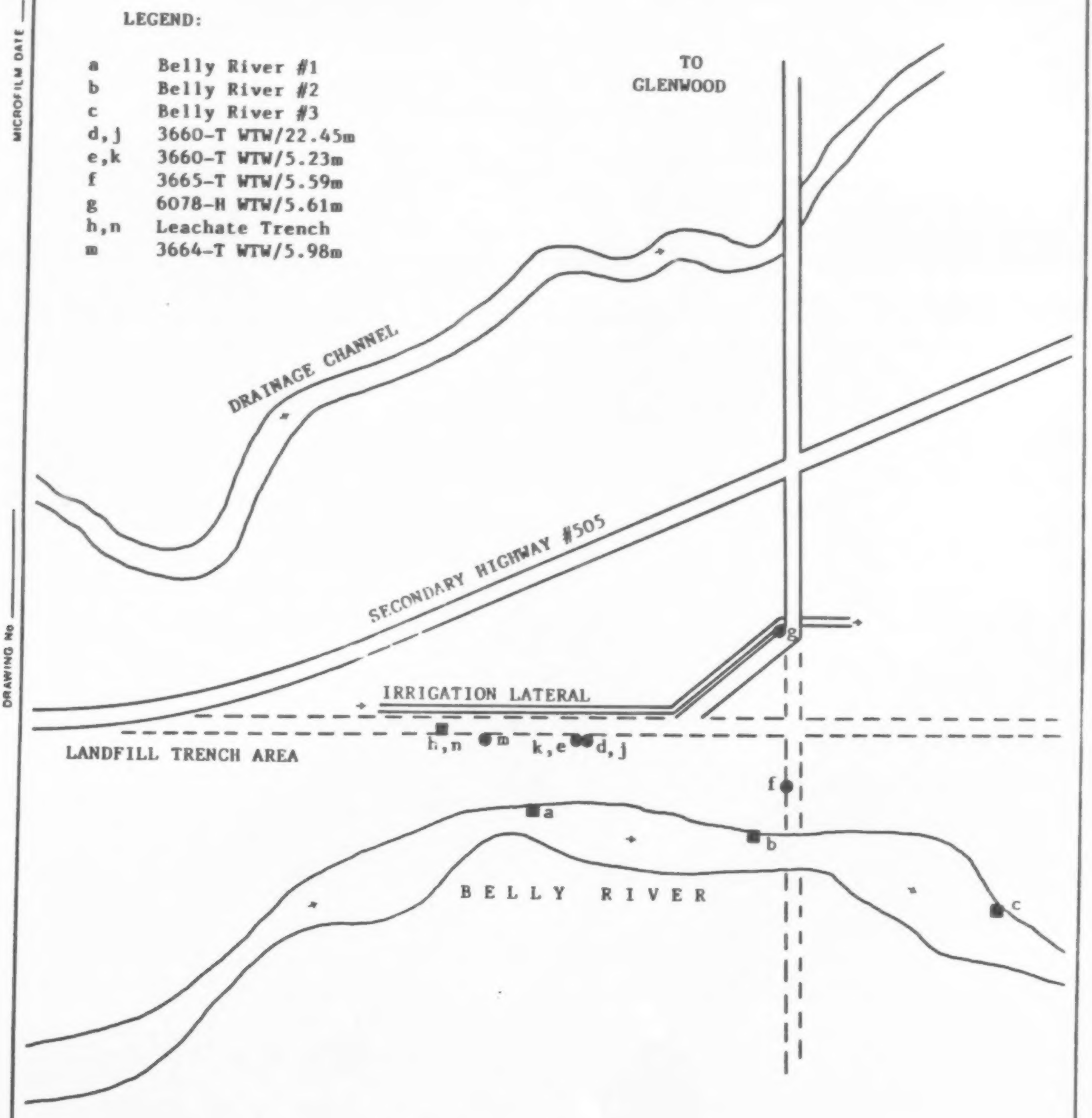
GROUNDWATER CONTAMINATION INVESTIGATION
GLENWOOD AREA (LANDFILL)
PT NE36-4-27-W4 & PT SE 1-5-27-W4

TEST HOLE LOCATIONS

SCALE 1:1500 SHEET [illegible] OF [illegible]
DATE NOVEMBER 1984 FIGURE No. 2

MICROFILM DATE

DRAWING No


LEGEND:
a Belly River #1
b Belly River #2
c Belly River #3
d,j 3660-T WTW/22.45m
e,k 3660-T WTW/5.23m
f 3665-T WTW/5.59m
g 6078-H WTW/5.61m
h,n Leachate Trench
m 3664-T WTW/5.98m
TO GLENWOOD
DRAINAGE CHANNEL
SECONDARY HIGHWAY #505
g
IRRIGATION LATERAL
LANDFILL TRENCH AREA
h,n
m
k,e
d,j
f
a
b
BELLY RIVER
c

Alberta ENVIRONMENT

SUBMITTED	DESIGNED R.M.C.	GLENWOOD LANDFILL CONTAMINATION INVESTIGATION
DATE Feb 14/86	CHECKED	GLENWOOD AREA - MUNICIPAL DISTRICT #6 Pt. N.E. 36-4-27-W4 & Pt. S.E. 1-5-27-W4 WATER SAMPLING LOCATIONS
APPROVED	DRAWN	SCALE N/A — SHEET OF
DATE Feb. 14/86	CHECKED	DATE NOVEMBER 1984 — FIGURE No. 3

FILE No

Table 1

GLENWOOD LANDFILL CONTAMINATION INVESTIGATION
Pt. N.E. 36-4-27-W4 & Pt. S.E. 1-5-27-W4

MONITORING WELL COMPLETION INFORMATION

Observation Well #	Type of * Observation	Date Installed	Observation Well Depth (m)	Height of Pipe Above Ground Surface (m)	Screened Interval (m)	Ground Elevation ** (m)	Elevation Top of Pipe (m)
3660-T	WTW	84/08/22	22.45	0.69	16.4 -22.45	1000.42	1001.11
3660-T	WTW	84/08/23	5.23	0.67	1.5 - 5.23	1000.42	1001.09
3664-T	WTW	84/08/23	5.98	0.59	1.5 - 5.98	1000.88	1001.47
3665-T	WTW	84/08/23	5.59	0.23	1.9 - 5.59	988.87	984.10
6078-H	WTW	79/09/13	5.61	0.42	0.0 - 5.61	999.45	999.87

* WTW - Water Table Well

** Elevation - Assumed Geodetic Metric

Table 2
WATER LEVEL DATA
GROUNDWATER ELEVATIONS (ASSUMED GEODETIC METRIC)

GLENWOOD LANDFILL CONTAMINATION INVESTIGATION - Pt. N.E. 36-4-27-W4
Pt. S.E. 1-5-27-W4

Well Number	Type/Depth* (m)	Monitor Ground Elev. (m)	1984-08-29		1984-09-06**		1984-09-07†		1984-10-16†		1984-10-23	
			Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.
3660-T	WTW/22.45	1000.42	3.52	996.90	12.49	987.93	13.05	987.37	6.74	993.68	6.19	994.23
3660-T	WTW/5.23	1000.42	3.06	997.36	2.94	997.48	4.14	996.28	1.71	998.71	2.70	997.72
3664-T	WTW/5.98	1000.88	Dry	994.90	Dry	-	Dry	-	4.91	995.97	4.71	996.17
3665-T	WTW/5.59	988.87	3.32	985.55	3.36	985.51	3.33	985.54	3.23	985.64	3.20	985.67
6078-H	WTW/5.61	999.45	Dry	993.84	Dry	-	1.03	998.42	0.79	998.66	0.63	998.82

* WTW - Water Table Well

** Instrumentation Baled out 1984-08-29

† Water Flowing in Irrigation Lateral

Table 3

GLENWOOD LANDFILL CONTAMINATION INVESTIGATION

Pt. N.E. 36-4-27-W4 & Pt. S.E. 1-5-27-W4

GROUNDWATER CHEMISTRY ANALYSES

(1984-09-07)* & (1984-10-23)†

Well Number	3660-T*	3660-T†	3660-T*	3660-T†	3664-T*	Leachate*	Leachate†
Type/Depth (m)	WTW/22.45	WTW/22.45	WTW/5.23	WTW/5.23	WTW/5.98	Trench (Filtered)	Trench (Unfiltered)
Lab Data							
pH	7.81	7.34	7.77	7.62	7.23	8.36	8.21
EC (mS/cm)	3.60	3.86	7.15	8.51	6.35	7.83	8.54
SAR	2.05	1.8	6.37	6.0	5.7	9.76	10.5
LAB ANALYSIS							
Inorganic (mg/L)							
Hardness	2465.0	2375.0	4300.0	4550.0	3100.0	1950.0	2000.0
Ca	522.0	490.0	448.0	438.0	440.0	100.0	80.0
Mg	281.88	279.45	772.74	839.56	486.0	413.1	437.4
Na	234.6	197.8	961.4	931.5	726.8	991.3	1076.8
HCO_3	456.89	498.98	391.01	400.16	431.88	2723.65	2606.53
CO_3							
Cl	11.52	9.75	63.81	77.99	19.5	1134.40	1364.82
SO_4	2419.2	2280.0	5760.0	6000.0	4051.2	734.4	950.4
K	14.86	11.73	18.38	16.42	16.81	317.10	342.52
NO_3-N	7.00	2.24	2.45	1.12	<0.07	0.14	<0.07
TDS (mg/L)	3740.0	3520.0	8228.0	8510.0	5950.0	5132.0	5610.0
Metals (mg/L)							
Fe	0.06	0.04	0.07	0.07	0.37	0.20	1.48
Mn	0.25	0.33	0.06	0.08	2.74	0.32	0.31
Cu	0.02	0.02	0.04	0.03	0.03	0.04	0.02
Zn	0.03	0.02	0.05	0.02	0.02	0.10	0.32
Pb	0.13	0.08	0.18	0.16	0.10	0.09	0.08
Cd							
Organic (mg/L)							
COD	23.6	14.7	61.4	108.0	157.0	283.0	363.0
TOC							
TIC							
TC							

Table 3 (cont)

GLENWOOD LANDFILL CONTAMINATION INVESTIGATION

Pt. N.E. 36-4-27-W4 & Pt. S.E. 1-5-27-W4

GROUNDWATER CHEMISTRY ANALYSES

(1984-09-07)

Well Number	3665-T	6078-H	Belly River	Belly River	Belly River	CDWS**
Type/Depth (m)	WTW/5.98	WTW/5.61	#1	#2	#3	
Lab Data						
pH	7.74	7.86	8.57	8.52	8.53	
EC (mS/cm)	0.53	1.26	0.16	0.16	0.18	
SAR	0.48	0.93	0.62	0.62	0.62	
LAB ANALYSIS						
Inorganic (mg/L)						
Hardness	345.0	850.0	127.5	127.5	127.5	500
Ca	86.0	124.0	30.0	30.0	30.0	NE***
Mg	31.59	131.22	12.76	12.76	12.76	150
Na	20.7	62.1	16.1	16.1	16.1	300
HCO_3	375.15	648.43	134.81	131.15	132.98	NE
CO_3			5.7	7.5	6.6	NE
Cl	1.77	2.66	1.77	<0.89	<0.89	250
SO_4	2.4	410.4	43.2	43.2	43.2	500
K	1.96	3.13	0.78	0.78	0.78	NE
NO_3-N	<0.07	<0.07	<0.07	<0.07	<0.07	10
TDS (mg/L)	408.	1053.	177.	175.	175.	1000
Metals (mg/L)						
Fe	0.33	0.11	0.35	0.18	0.10	0.3
Mn	0.54	0.29	0.02	0.01	0.01	0.05
Cu	<0.01	0.01	<0.01	0.01	<0.01	1.0
Zn	0.01	0.02	0.01	0.01	<0.01	5.0
Pb	0.04	0.07	0.06	0.06	0.04	0.05
Cd						
Organic (mg/L)						
COD	14.2	37.8	<4.7	9.4	9.4	
TOC						
TIC						
TC						

** CDWS - Canadian Drinking Water Standard

***NE - Not Established

SOILS BRANCH DRILL HOLE LOG

Land Location N.W. **Sec.** 36 **Tp.** 4 **R.** 27 **W** 4

Date August 22, 1984 **Supervisor**

Project Glenwood Landfill Investigation

Test Hole 3660-T, 3664-T, 3665-T and 6078-H **inclusive.**

Test Hole 3660-T

DEPTH (m)	**TEXTURE AND LITHOLOGY**	**MOISTURE CONTENT***
0- 0.75	lacustrine, sandy silt, traces of gravel	d
0.75- 2.0	till, sand and clay, pebbles oxidized	sm
2.0 - 3.0	till, clay and sand	m
3.0 - 4.5	till, clay, medium dark brown, pebbles, oxidized	m
4.5 - 5.25	till, clay, medium dark brown, small amount of fine sand	sm
5.25- 6.25	till, clay, medium dark brown, small coal chips	sm
6.25- 7.5	till, fine sandy clay, medium brown, pebbles	m
7.5 -10.5	till, fine sandy clay, medium brown, gravelly	sm
10.5 -15.2	till, very fine sandy clay, medium brown, gravelly	sm
15.2 -17.0	till, very fine sandy clay, darker brown, small pebbles	m
17.0 -18.6	reduced till, clay, black-grey, pebbles	m
18.6 -22.8	reduced till, clay, dark brown-grey, tiny pebbles	m

***Moisture Content:** d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole 3664-T		
0- 0.50	Top soil, fine sandy, beige colour	d
0.5 - 1.5	Sandy till, fine grained, light brown	d
1.5 - 3.0	Till, clay, medium brown, sandstone chips, coal	m
3.0 - 4.5	Till, fine sandy clay, medium brown sandstone chips, coal	m
4.5 - 6.1	Till, fine sandy clay, yellowish brown, pebbles	sm
Test Hole 3665-T		
0- 1.5	Fill material, sand, clay, garbage, etc.	d
1.5 - 2.25	Top soil, clay, black organic	sm
2.25- 3.75	Lacustrine, clay, black colour	m-sm
3.75- 4.25	Lacustrine, clay, black colour	m-sm
4.25- 4.5	Fine sand and gravel, grey colour	vm-sat
4.5 - 5.8	Till, clay, brown, pebbles, bedrock chips	m
Test Hole 6078-H		
0- 0.3	Top soil, clayey sand	sm
0.3 - 1.5	Till, clay and sand	m
1.5 - 3.4	Till, sandy clay	vm
3.4 - 6.1	Till, clay	m

*Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

HARTELL RECLAIMED LANDFILL

NE 9-19-2-W5

LOCATION AND SITE DESCRIPTION

- located 1.6 km east of Hartell (Figure 1);
- the site lies at the western edge of a coulee;
- an intermittent stream in the coulee runs toward the south and forms a tributary to Tongue Creek;
- primarily domestic refuse was reportedly disposed of at the site;
- the disposal site, approximately 0.5 ac (0.2 ha) in area, has been reclaimed.

FIELD PROGRAM

Test Drilling and Monitor Completion

- two test holes were drilled (locations shown in Figure 2 and borehole logs attached);
- 2 water table wells were installed;
- a single well response test was conducted on W456.

Monitoring

- water levels recorded on September 6, 1985;

Well Number	Water level, m (below ground level)
W455	9.02
W456	4.96

- groundwater samples were collected for chemical analysis on September 16, 1985 (Table 1).

STUDY RESULTS

Geology

- clayey to sandy textured till, containing cobbles, is the predominant surficial material;
- surficial materials are at least 12 m thick.

Hydrogeology

- shallow groundwater flow is east toward the coulee;

- the site is located in a groundwater recharge area;
- surficial materials have a hydraulic conductivity $<10^{-4}$ cm/s.

Hydrochemistry

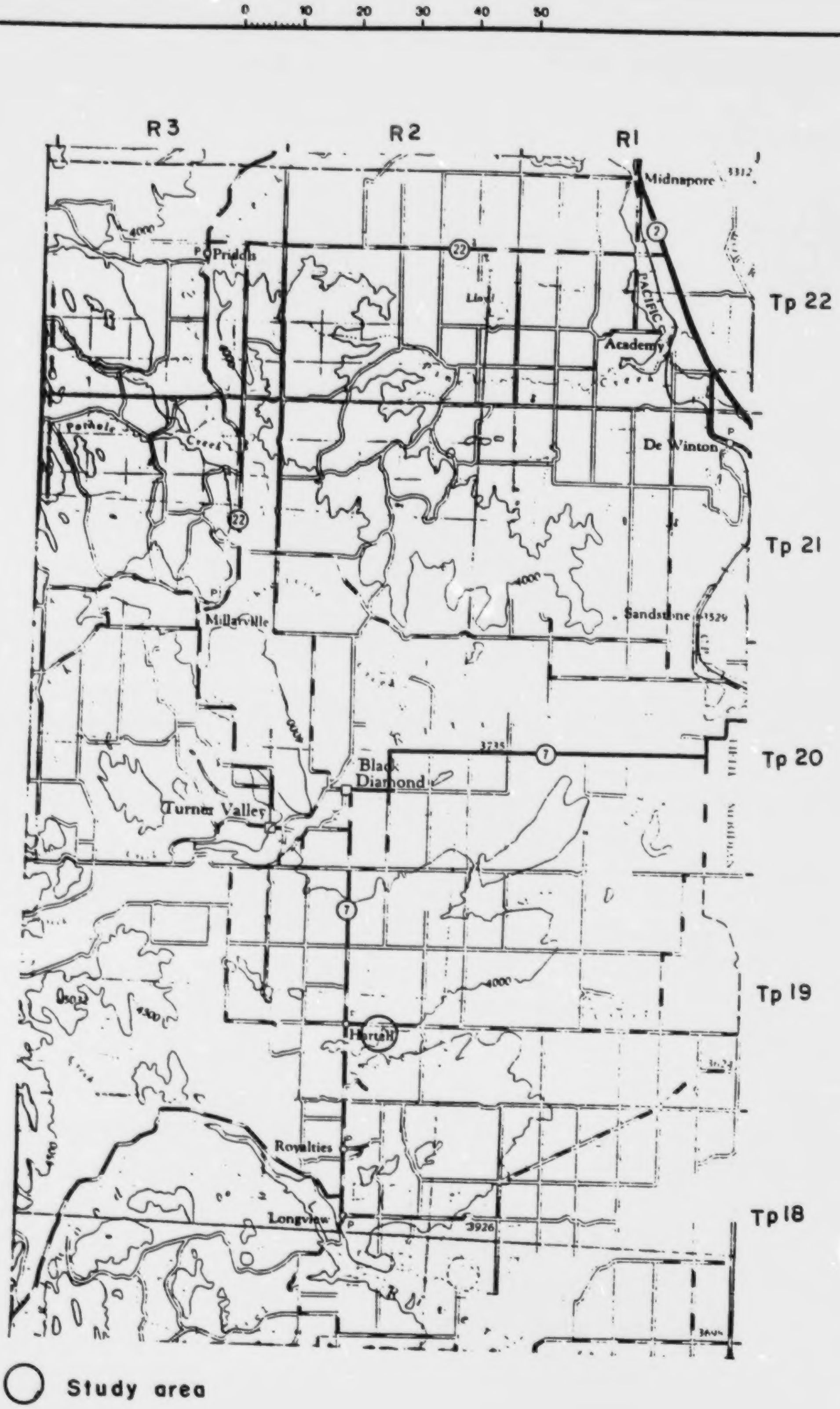
- shallow groundwater is the calcium-magnesium/bicarbonate type with a total dissolved solids concentration <500 mg/L;
- groundwater from W456, located adjacent the landfill, has a higher chloride concentration than background water suggesting that the water is contaminated.
- no chemical constituents exceed Canadian Drinking Water Standards;
- no organic contamination detected.

CONCLUSIONS

- landfill area is underlain by low permeability till;
- shallow groundwater is of good quality;
- groundwater adjacent the refuse is contaminated; however, the level of contamination is very low with no constituents exceeding upper limits for Canadian Drinking Water.

RECOMMENDATIONS

- it is recommended that monitoring at the site be discontinued and that the site be downgraded to low priority.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10
20
30
40
50
R3
R2
R1
Midnapore
3312
2
Priddis
22
Lloyd
Tp 22
PACIFIC
Academy
Creek
Pothole
Creek
De Winton
22
Tp 21
4000
Sandstone
Millarville
3735
7
Tp 20
Black Diamond
Turner Valley
7
4000
Tp 19
Hartell
Royalties
Longview
3926
Tp18
Study area

MICROFILM DATE

DRAWING No

FILE No.

Alberta
ENVIRONMENT

SUBMITTED W. J. Cuin
DATE Feb 14/86
APPROVED F. J. McCracken
DATE Feb 14/86

DESIGNED N.T.S. (1960)
CHECKED
DRAWN M.D.
CHECKED

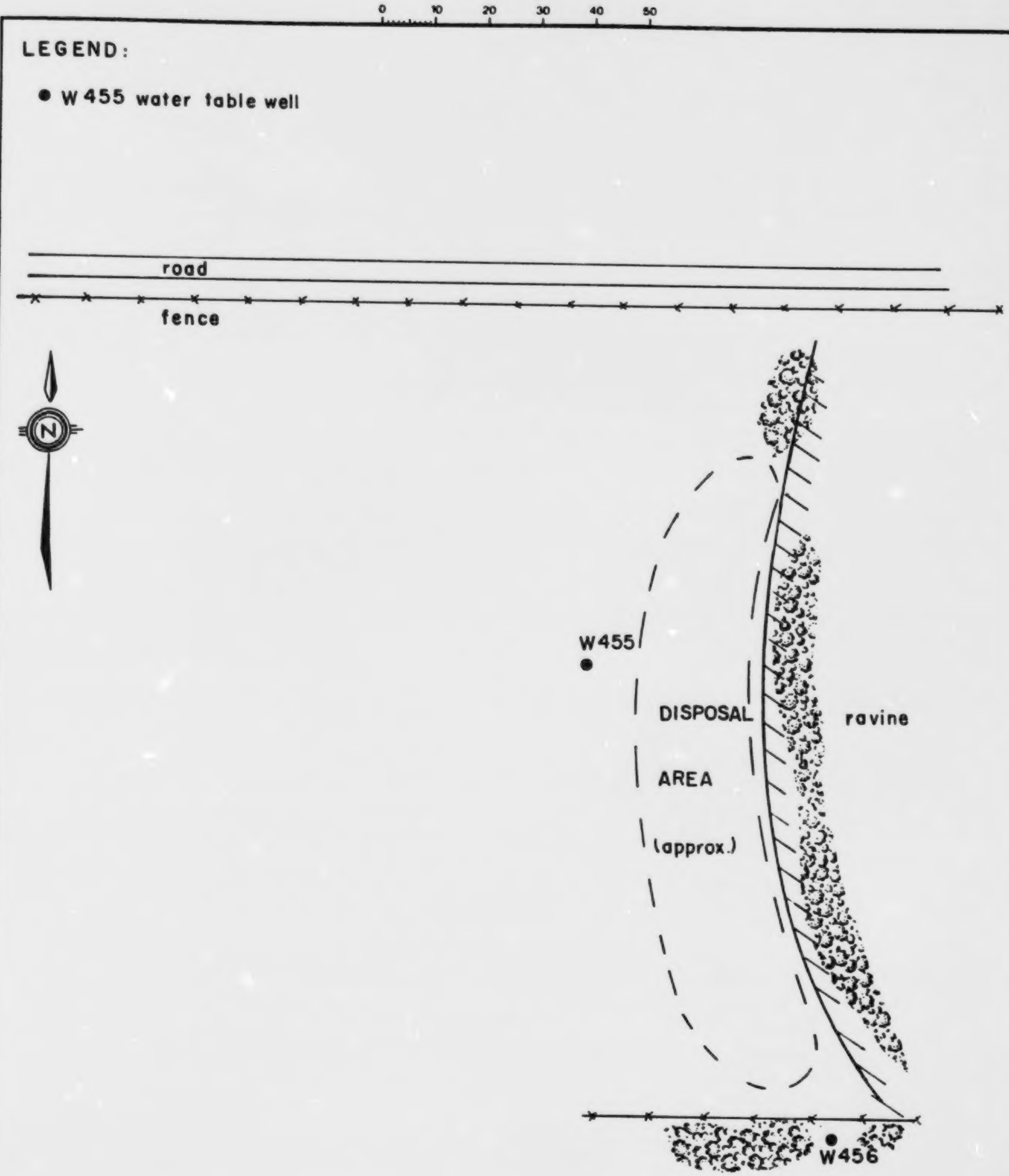
HARTELL RECLAIMED LANDFILL

LOCATION MAP

SCALE 1 = 250 000
DATE
SHEET OF
FIGURE No. 1

MICROFILM DATE

DRAWING No


0
10
20
30
40
50
LEGEND:
● W455 water table well
road
fence
N
W455
DISPOSAL
AREA
(approx.)
ravine
W456

Alberta ENVIRONMENT

HARTELL RECLAIMED LANDFILL

SITE PLAN

SUBMITTED
DATE Feb. 14/86

APPROVED C. McCracken
DATE Feb 14/86

DESIGNED W.C.
CHECKED

DRAWN M.D.
CHECKED

SCALE not to scale.
DATE

SHEET OF
FIGURE No. 2

FILE No.

TABLE 1: GROUNDWATER CHEMISTRY ANALYSES

	Well Numbers		C.D.W.S.*
	W455	W456	
LAB ANALYSIS - all parameters in mg/L			
Inorganic			
Ca	53	90	
Mg	25.5	30.4	150
K	3.5	2.7	
Na	32.2	36.8	300
Cl	1.8	63.8	250
SO_4	57.6	55.2	500
HCO_3	313	348	
NH_4-N	0.2	0.2	1
NO_3-N	0.5	6.2	10
Total Hard.	238	350	500
T.D.S.	329	463	1000
Metals			
Fe	0.02	0.02	0.3
Mn	0.07	0.21	0.05
Cu	<0.01	<0.01	1.0
Zn	0.02	0.01	5.0
Pb	0.03	0.03	0.05
Organics			
COD	4	14	
Other			
pH	8	7.9	
E.C. (mS/cm)	0.6	0.8	
S.A.R.	0.91	0.86	

* Canadian Drinking Water Standards

SOILS BRANCH DRILL HOLE LOG

Land Location NE Sec. 9 Tp. 19 R. 2 W. 4

Date August 27, 1985 Supervisor M. deBrentani

Project Hartell reclaimed Landfill

Test Hole 455 to 456 inclusive.

Test Hole 455

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - 7	till, sandy clay, brown, gravelly, friable	d
7 - 12	till, silty clay, grey, clayey	sm - vm

Installation: water table well, 12 m deep, slotted 6 - 12 m below ground level, 2" PVC pipe.

Test Hole #456

0 - 5.5	till, sandy clay, brown, gravelly, friable	d
5.5 - 7	till, sandy clay, dark brown, friable, some pebbles	sm - vm
7 - 9	till, silty clay, brown, plastic	s

Installation: watertable well, 9 m deep, slotted 4.5 - 9 m b.g.l., 2" PVC pipe.

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

HIGH PRAIRIE RECLAIMED LANDFILL

NE 23-74-17-W5

LOCATION AND SITE DESCRIPTION

- the site is located in the southwest corner of High Prairie (Figure 1), east of West Prairie River;
- a daycare centre has been constructed on the reclaimed landfill site;
- the site has little relief and slopes toward the West Prairie River;
- primarily domestic refuse was disposed of at the site;
- the area of the disposal site is approximately 2.5 ac (1 ha).

FIELD PROGRAM

Test Drilling and Monitor Completion

- five testholes were drilled at five locations (locations are shown in Figure 1 and borehole logs are attached);
- five water table wells were installed in the boreholes (completion details contained in Table 1).

Monitoring

- water levels were recorded on two occasions (Table 2);
- groundwater samples were collected for analysis on October 10, 1985 (Table 3).

EM Survey

- terrain conductivity surveys were conducted using the EM-31 instrument in the vertical mode (approximate depth of 3 m) and in the horizontal mode (approximate depth of 6 m);
- location of measurement points and conductivity values shown in Figure 3 and 4.

STUDY RESULTS

Geology

- the shallow geology of the site has been disrupted by the area fill type landfill and extensive contruction in the area;

- the surficial geology in the landfill area consists of up to 6 m of refuse overlying fine to medium grained sand up to 5 m thick. The sand overlies clay (Figure 5);
- a study completed by the Groundwater Protection Branch of Alberta Environment on March 2, 1976 revealed the presence of up to 6 m of refuse in the vicinity of the daycare building. In addition, flammable gases were found in the refuse.
- in the floodplain area, up to 6 m of till (clay fill?) overlies sand.

EM Survey

- terrain conductivity survey results are shown in Figures 3 and 4;
- the highest conductivity values coincide with the landfill area;
- west of the day care centre the high conductivity area appears to extend off site. However, a transect between the landfill and river shows low conductivity values.

Hydrogeology

- the predominant direction of shallow groundwater flow is to the west, toward the West Prairie River, under the influence of a very shallow horizontal hydraulic gradient (Figure 5);
- the water table appears to be hydraulically connected to the river;
- based on visual grain size analysis, the hydraulic conductivity of the sand is in the order of 10^{-4} cm/s.

Groundwater Chemistry

- due to access problems and uncertainty about the limits of the landfill, it was difficult to install monitors upgradient from the landfill;
- groundwater from W366, is probably the most representative of background quality conditions. The water is the calcium/magnesium-bicarbonate type with a total dissolved solids <700 mg/L. Elevated concentrations of chloride, ammonium, iron and manganese suggest that even this water may be slightly contaminated by leachate;

- groundwater from W362 and W365, completed in the sand below the refuse, and groundwater from W363 and W364, located down-gradient from the landfill is contaminated by leachate. The waters tend to be more mineralized and have higher sulphate, ammonium, iron and manganese concentrations than background water;
- the unusually high sulphate, iron and manganese concentration in water from W364 suggest that the well may be completed in or near refuse or that there may be an analytical error. If so, the water may not be representative of down-gradient water quality conditions;
- expectedly, the organic load of groundwater beneath the refuse is the highest. The organic content of all groundwater in the area is low;
- excluding groundwater from W364, only total hardness, total dissolved solids, iron and manganese concentrations slightly exceed upper limits for Canadian Drinking Water.

CONCLUSIONS

- the EM Survey and water chemistry data suggest that groundwater beneath and possibly down-gradient from the landfill has been contaminated by leachate;
- the level of contamination, with the exception of groundwater from W364, is generally low.

RECOMMENDATIONS

- it is recommended that a replicate sample be collected from W364 to check analytical results. If high sulphate, iron and manganese concentrations are confirmed, additional drilling-monitor installation and sampling will be required to establish the areal extent of the high concentrations;
- even though it is not expected river water has been contaminated, it is recommended that water samples be collected from the river upstream and downstream from the landfill area.

MICROFILM DATE

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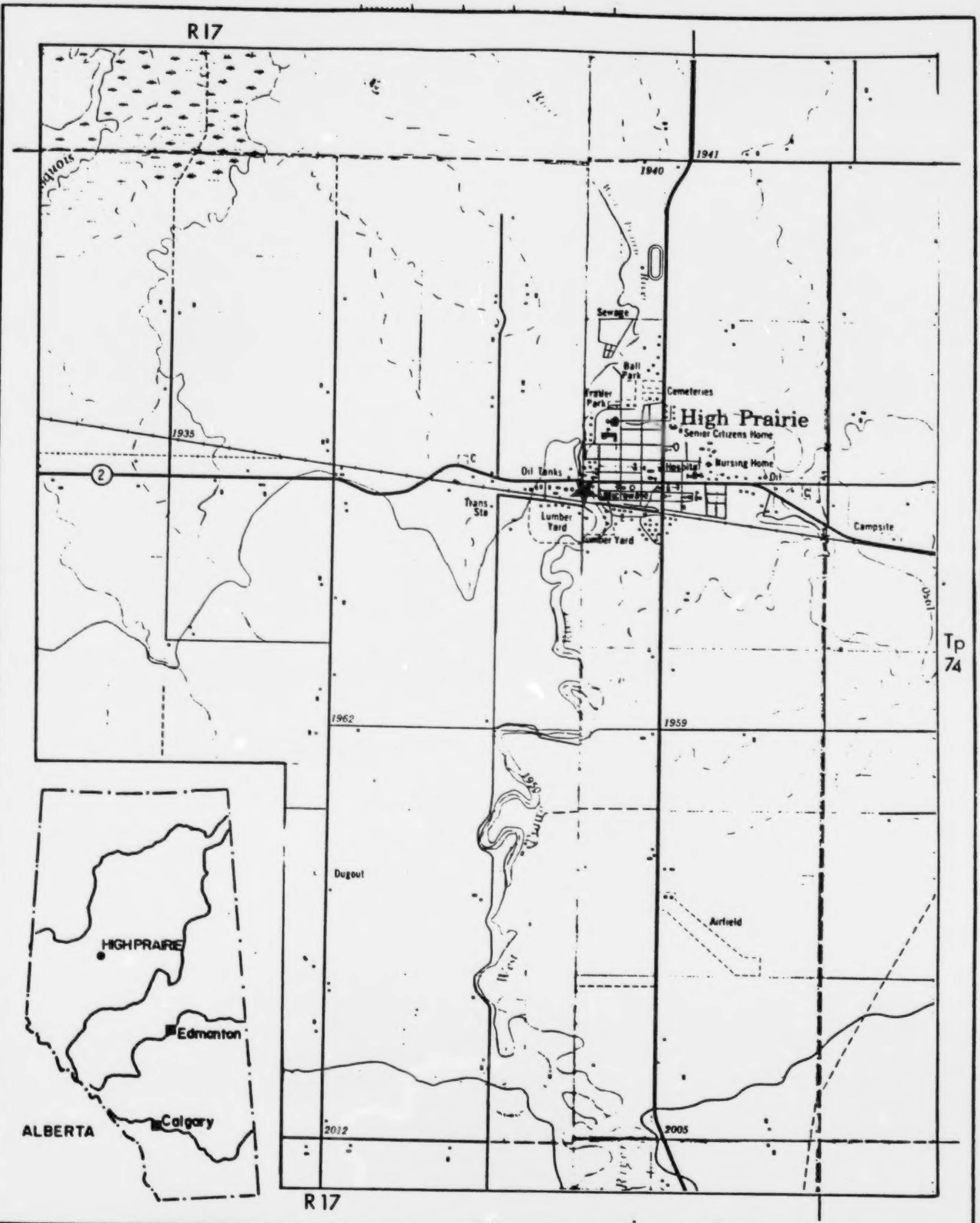

R17
1941
1940
River
Sewage
Ball Park
Trailer Park
Cemeteries
High Prairie
Senior Citizens Home
1935
2
Oil Tanks
Hospital
Nursing Home
Oil
Trans. Stn
Lumber Yard
Lumber Yard
Campsite
Tp 74
1962
1959
Dugout
Airfield
West Prairie River
2012
2005
HIGH PRAIRIE
Edmonton
Calgary
ALBERTA
R17

FILE No.

Alberta
ENVIRONMENT

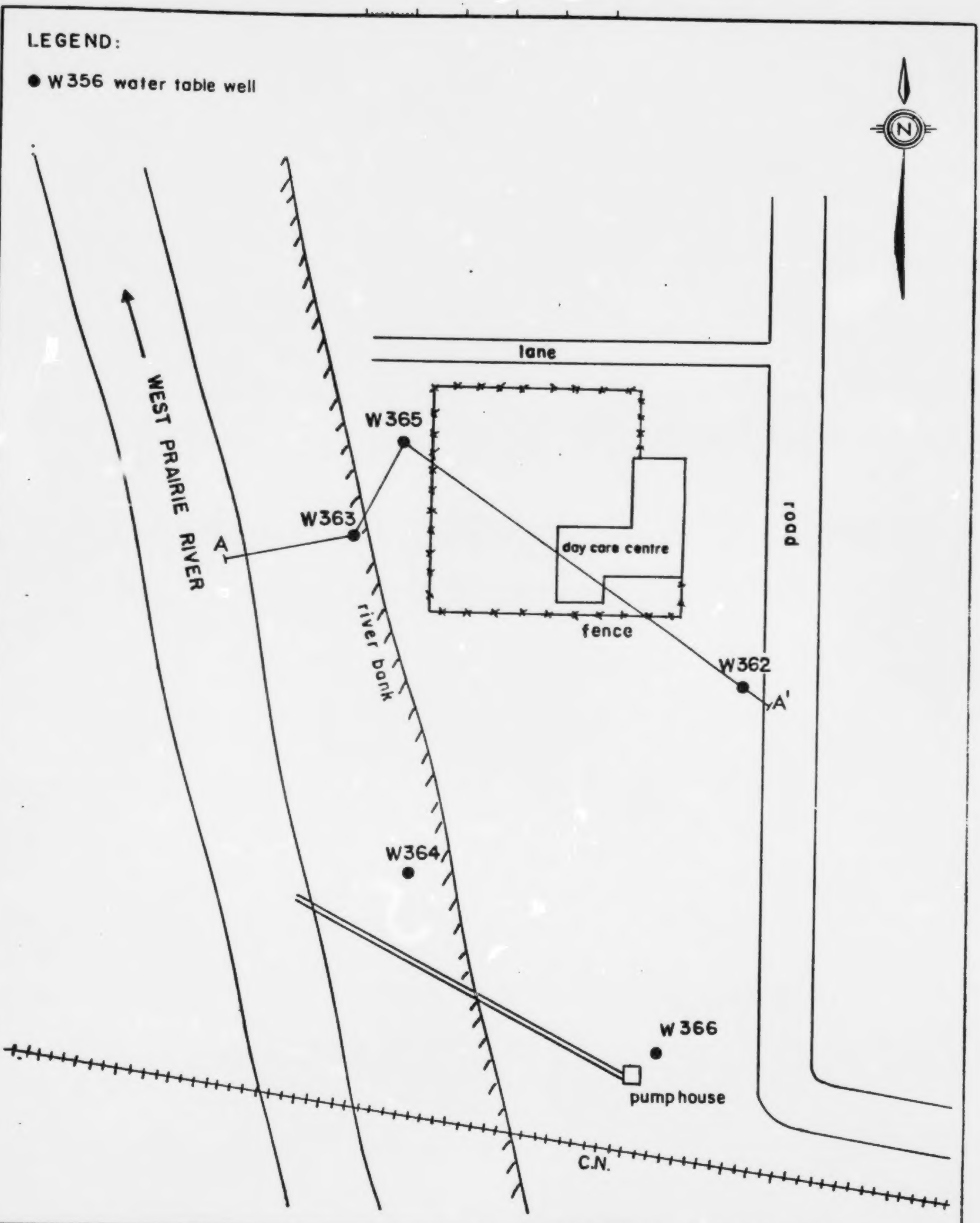
SUBMITTED W. J. Lewis
DATE Feb. 14/86
APPROVED L. McCracken
DATE Feb 14 86

DESIGNED
CHECKED
DRAWN
CHECKED

HIGH PRAIRIE RECLAIMED LANDFILL

LOCATION PLAN

SCALE 1=50000
DATE
SHEET OF
FIGURE No. 1


LEGEND:
● W356 water table well
N
WEST PRAIRIE RIVER
river bank
lane
road
W365
W363
A
day care centre
fence
W362
A'
W364
W366
pump house
C.N.

MICROFILM DATE

DRAWING No

FILE No

Alberta ENVIRONMENT

SUBMITTED W. A. Cowie

DATE Feb. 14/86

APPROVED J. K. McCracken

DATE Feb. 14/86

DESIGNED R.J.

CHECKED

DRAWN M.H.

CHECKED

HIGH PRAIRIE RECLAIMED LANDFILL

SITE PLAN (a cross section)

SCALE 1=1000

DATE

SHEET OF

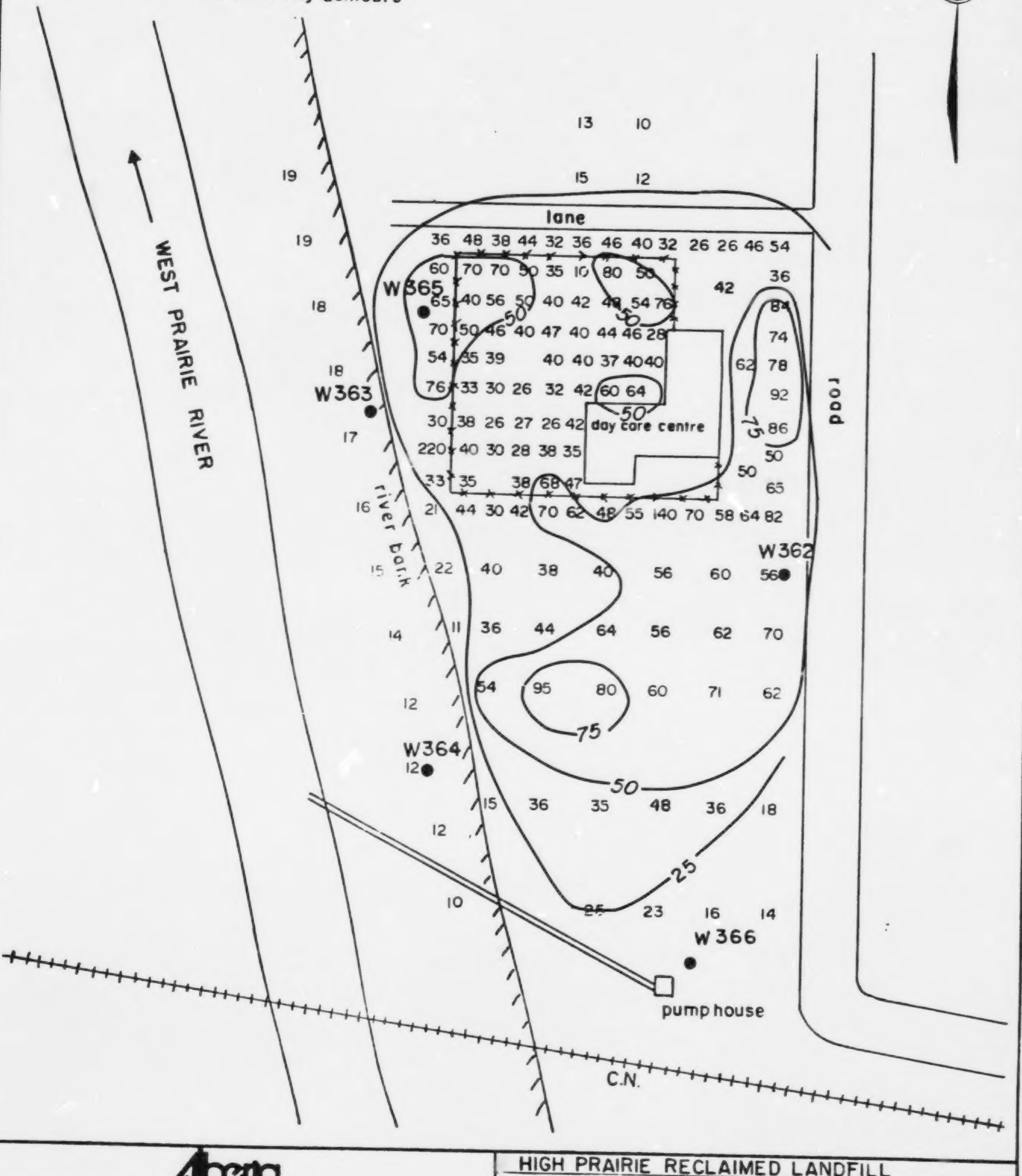
FIGURE No. 2

LEGEND:

● W356 water table well

82 Measuring Station (mS/cm)

—75— Terrain Conductivity Contours


N
WEST PRAIRIE RIVER
river bank
lane
road
day care centre
W365
W363
W362
W364
W366
pump house
C.N.
13 10
15 12
19
19
18
18
17
16
15
14
12
12
12
10
36 48 38 44 32 36 46 40 32 26 26 46 54
60 70 70 50 35 10 80 50
65 40 56 50 40 42 48 54 76 42 36
70 50 46 40 47 40 44 46 28 84 74
54 35 39 40 40 37 40 40 62 78
76 33 30 26 32 42 60 64 92
30 38 26 27 26 42 86
220 40 30 28 38 35 50
33 35 38 68 47 50 65
21 44 30 42 70 62 48 55 140 70 58 64 82
22 40 38 40 56 60 56
11 36 44 64 56 62 70
54 95 80 60 71 62
15 36 35 48 36 18
25 23 16 14
50
75
25

MICROFILM DATE

DRAWING No

FILE No

Alberta
ENVIRONMENT

SUBMITTED W. J. Geoin
DATE Feb. 14/86.
APPROVED
DATE Feb. 14/86

DESIGNED
CHECKED
DRAWN M.H.
CHECKED

HIGH PRAIRIE RECLAIMED LANDFILL

TERRAIN CONDUCTIVITY

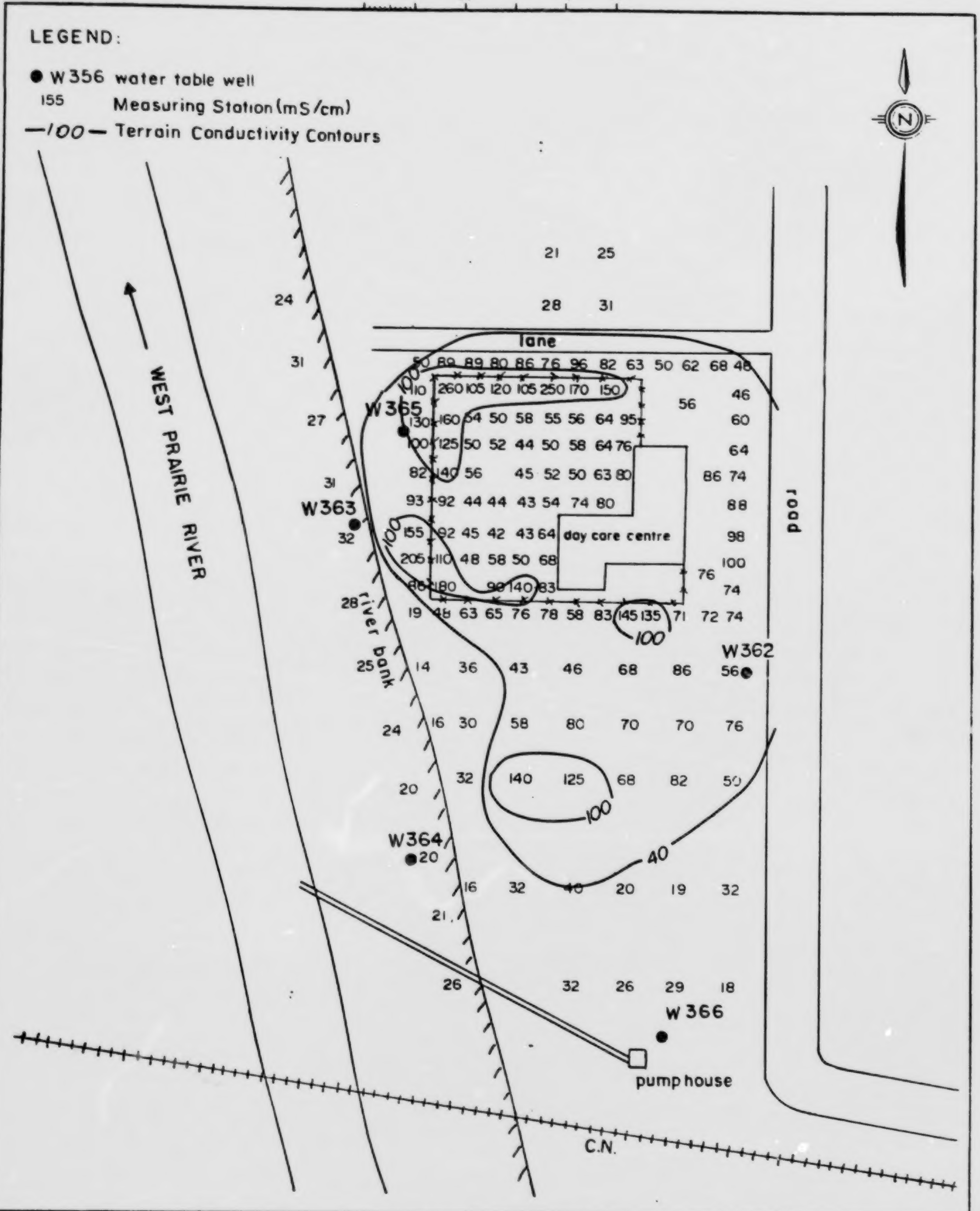
approx. 3m below ground level

SCALE 1=1000
DATE
SHEET OF
FIGURE No. 3

MICROFILM DATE

DRAWING No

FILE No


LEGEND:
● W356 water table well
155 Measuring Station (mS/cm)
—100— Terrain Conductivity Contours
N
WEST PRAIRIE RIVER
river bank
lane
road
day care centre
pump house
C.N.
W365
W363
W362
W364
W366
100
100
100
100
40
21 25
28 31
24
31
50 89 89 80 86 76 96 82 63 50 62 68 48
110 260 105 120 105 250 170 150 46
27 130 160 54 50 58 55 56 64 95 56 60
100 125 50 52 44 50 58 64 76 64
31 82 140 56 45 52 50 63 80 86 74
93 92 44 44 43 54 74 80 88
32 155 92 45 42 43 64 98
205 110 48 58 50 68 100
86 180 90 140 83 76 74
28 19 48 63 65 76 78 58 83 145 135 71 72 74
25 14 36 43 46 68 86 56
24 16 30 58 80 70 70 76
20 32 140 125 68 82 50
20
16 32 40 20 19 32
21
26 32 26 29 18

Alberta ENVIRONMENT

SUBMITTED
DATE Feb. 14 '86

APPROVED
DATE Feb 14/86

DESIGNED
CHECKED

DRAWN M.H.
CHECKED

HIGH PRAIRIE RECLAIMED LANDFILL

TERRAIN CONDUCTIVITY

approx. 6m below ground level

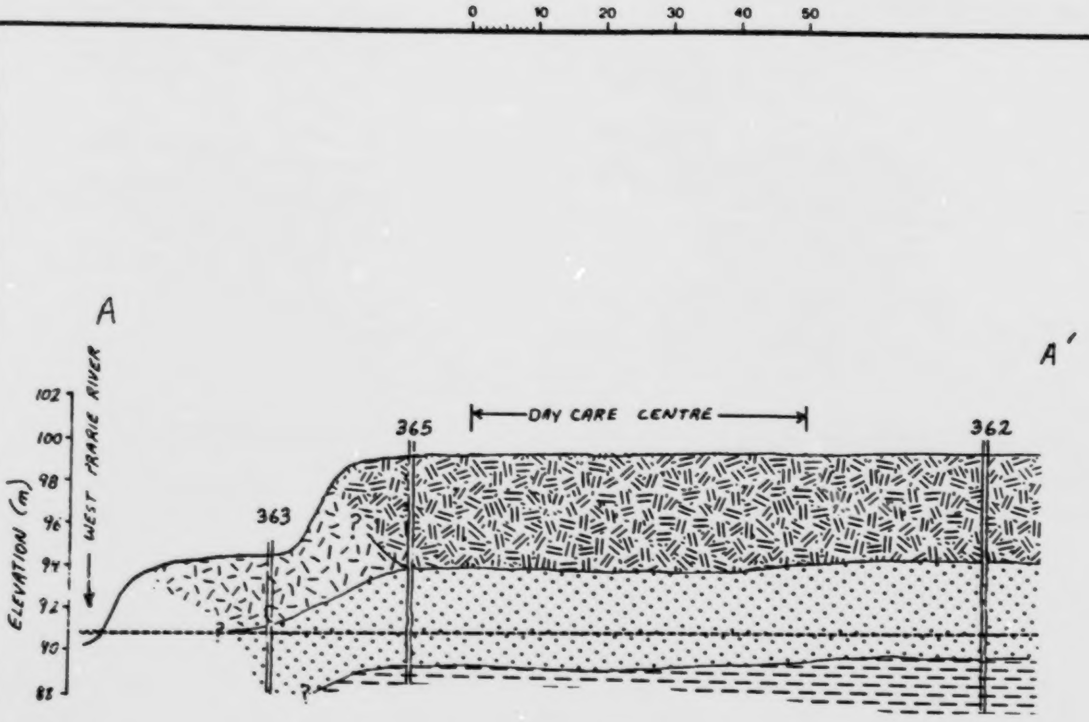
SCALE 1=1000

DATE

SHEET OF

FIGURE No. 4

MICROFILM DATE


0
10
20
30
40
50
A
A'
ELEVATION (m)
102
100
98
96
94
92
90
88
WEST PRARIE RIVER
DAY CARE CENTRE
363
365
362
?

LEGEND

▨	TILL (CLAY FILL ?)
▩	FILL AND REFUSE
░	SAND
☰	CLAY
--------	WATER TABLE (AUGUST 19, 1985)

Horizontal Scale 1:1000

DRAWING No

FILE No.

Alberta
ENVIRONMENT

SUBMITTED N.J.
DATE Feb. 14/86
APPROVED
DATE Feb. 14/86

DESIGNED
CHECKED
DRAWN
CHECKED

HIGH PRARIE RECLAIMED LANDFILL

HYDROGEOLOGIC
CROSS-SECTION A-A'

SCALE
DATE
SHEET OF
FIGURE No. 5

TABLE 1: MONITORING WELL COMPLETION

Well Number	Date Installed	Well Depth (m)	Height of pipe above ground surface (m)	Screened interval (m)	Ground elevation (m)	Elevation of pipe (m)	Pipe diameter (mm)
W362	24 7 85	10	.69	5 - 10	99.90	100.59	50
W363	24 7 85	5	.83	2 - 5	94.93	95.76	50
W364	24 7 85	5	.86	5 - 9	94.84	95.70	50
W365	24 7 85	9	1.08	5 - 9	99.42	100.50	50
W366	24 7 85	10	1.20	5.5 - 10	99.92	101.12	50

TABLE 2: WATER LEVEL DATA

	Water Level (85/08/14)		Water Level (85/10/09)	
Well Number	Depth (b.g.l.) (m)	Elevation (m)	Depth (b.g.l.) (m)	Elevation (m)
W362	8.71	91.19	8.40	91.50
W363	4.02	90.91	3.55	91.38
W364	3.84	91.00	3.57	91.27
W365	8.15	91.27	7.87	91.55
W366	8.49	91.43	8.15	91.77

TABLE 3: WATER ANALYSIS RESULTS

	Well Numbers					C.D.W.S.
	362	363	364	365	366	
LAB DATA						
pH	7.93	8.13	5.47	7.62	7.92	
EC (mS/cm)	1.09	1.60	2.23	1.59	1.10	
SAR	.8	.6	.2	.7	.3	
LAB ANALYSIS (all parameters in mg/L)						
Inorganic						
Ca	147	242	500	198	165	NE
Mg	46.8	63.6	57	60	41.4	150
$CaCO_3$ (T. Hard.)	560	870	1485		585	500
Na	43.9	39.3	13.9	41.6	18.5	300
K	7.4	5.08	3.91	3.91	2.35	NE
HCO_3	693.57	512	15.25	781.4	642.94	NE
$CaCO_3$ (T. Alk.)	568.5	419	12.5	640.5	527	500
SO_4	76.8	360	1416	98.4	48	500
Cl	15.95	114.33	23.04	86.85	40.77	250
NO_3-N + NO_2-N	.84	.35	<.07	.14	.04	10
NH_4-N	4.41	.21	2.24	3.9	3.15	0.5
TDS	910	1077	2021	877	632	1000
Organic						
COD	88	41	34	78	49	
Metals						
Fe	25.4	.14	162	44.2	15	.03
Mn	1.87	1.19	107	3.16	2.12	0.05
Cu	.01	.02	.21	.01	.02	1.0
Zn	.04	.03	.08	.04	.04	5.0
Pb	.05	.05	.02	.05	.01	0.05

* Canadian Drinking Water Standards

** Not Established

SOILS BRANCH DRILL HOLE LOG

Land Location NE Sec. 23 Tp. 74 R. 17 W 5

Date July 24, 1985 Supervisor R.J.

Project Abandoned Landfill Investigation - High Prairie

Test Hole 85-362 to 85-366 inclusive.

Test Hole 362 (W)

DEPTH (m)	DEPOSIT	DESCRIPTION	M.C.*
0.0-0.3	sand-fill	brown, coarse grained, dirty	d
0.3-1.2	till-fill	dark grey, very sandy, trace of organics	d - sm
1.2-5.2	garbage	black, organics & clay	d - sm
5.2-7.3	sand	black, coarse grained, clayey	sm
7.3-8.5	sand	grey, some black layers, medium grained	sm
8.5-9.8	sand	a/a, thin silty clay layers, fine-medium grained	s
9.8-11.0	clay	dark grey, silty, firm, medium plastic	vm
11.0-12.2	clay	olive-grey, silty, thin medium grained sand lenses at 11.7 m, firm, medium-high plastic	m

Slough at 9.1 m at completion
Completed: 50 mm PVC watertable well
slotted interval: 5.1 - 9.7 m

*M.C. (Moisture Content): d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	DEPOSIT	DESCRIPTION	M.C.*
Test Hole 363 (W)			
0.0-3.7	till (fill?)	grey-brown, sandy, a few grey layers, trace of oxides, stiff, medium plastic	sm - m
3.7-4.9	sand	brown, coarse texture, loose	s
4.9-6.1	sand	grey, complex mixture of sand, silt & clay layers with some organics & wood (recent river deposits?)	s

Slough at 4.0 m at completion
Completed: 50 mm PVC
watertable well
slotted interval: 1.8 - 4.8 m

Test Hole 364 (W)			
0.0-1.8	till (fill?)	brown & grey, sandy, a few pebbles, stiff, medium plastic	d - sm
1.8-2.7	sand	brown, silty, medium grained, loose	sm - m
2.7-3.0	sand	a/a, grey	s
3.0-4.3	sand	dark grey, silty, numerous silt clay layers, soft	s
4.3-6.1	sand	grey, coarse grained, complex mixture of wood, organic silt and clay lenses (recent river deposit?)	s

Slough at 4.3 m at completion
Completed: 50 mm PVC watertable well
slotted interval: 2.2 - 5.2 m

*M.C. (Moisture Content): d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	DEPOSIT	DESCRIPTION	M.C.*
Test Hole 365 (W)			
0.0-1.5	till-fill	brown clay, sandy	d - sm
1.5-5.2	garbage	dark grey-black, some clay layers	sm - m
5.2-6.7	sand	black, clayey	m
6.7-10.1	sand	dark grey, medium grained, a few thin silt & silty clay layers, trace of organics, loose	s
10.1-10.7	clay	olive grey, silty, soft, medium plastic	m

Slough at 8.5 m at completion
Completed: 50 mm PVC watertable well
slotted interval: 4.7 - 9.3 m

Test Hole 366 (W)			
0.0-2.1	clay	brown & dark brown, very silty, some fine sand, firm	sm
2.1-4.9	sand	brown, fine-medium grained, silty	sm
4.9-5.8	sand	grey, silty-clayey	m
5.8-7.0	sand	dark grey, silty, a few thin clayey lenses, trace of organics	m
7.0-7.9	sand	grey, medium grained, trace of silt	m
7.9-10.7	sand	a/a	s
10.7-12.2	clay	olive grey, silty, firm, medium-high plastic	vm

Slough at 8.2 m at completion
Completed: 50 mm PVC watertable well
slotted interval: 5.5 - 10.1 m

*M.C. (Moisture Content): d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

KINBROOK ISLAND PROVINCIAL PARK LANDFILL

Pt. N.E. 19-17-14-W4

LOCATION AND SITE DESCRIPTION

- The site is located on the northeast tip of Kinbrook Island in Lake Newell (Figure 1);
- site is approximately 1 ha in size;
- site was submerged under approximately 0.45 to 0.6 m of water during 1985 (Figure 2).

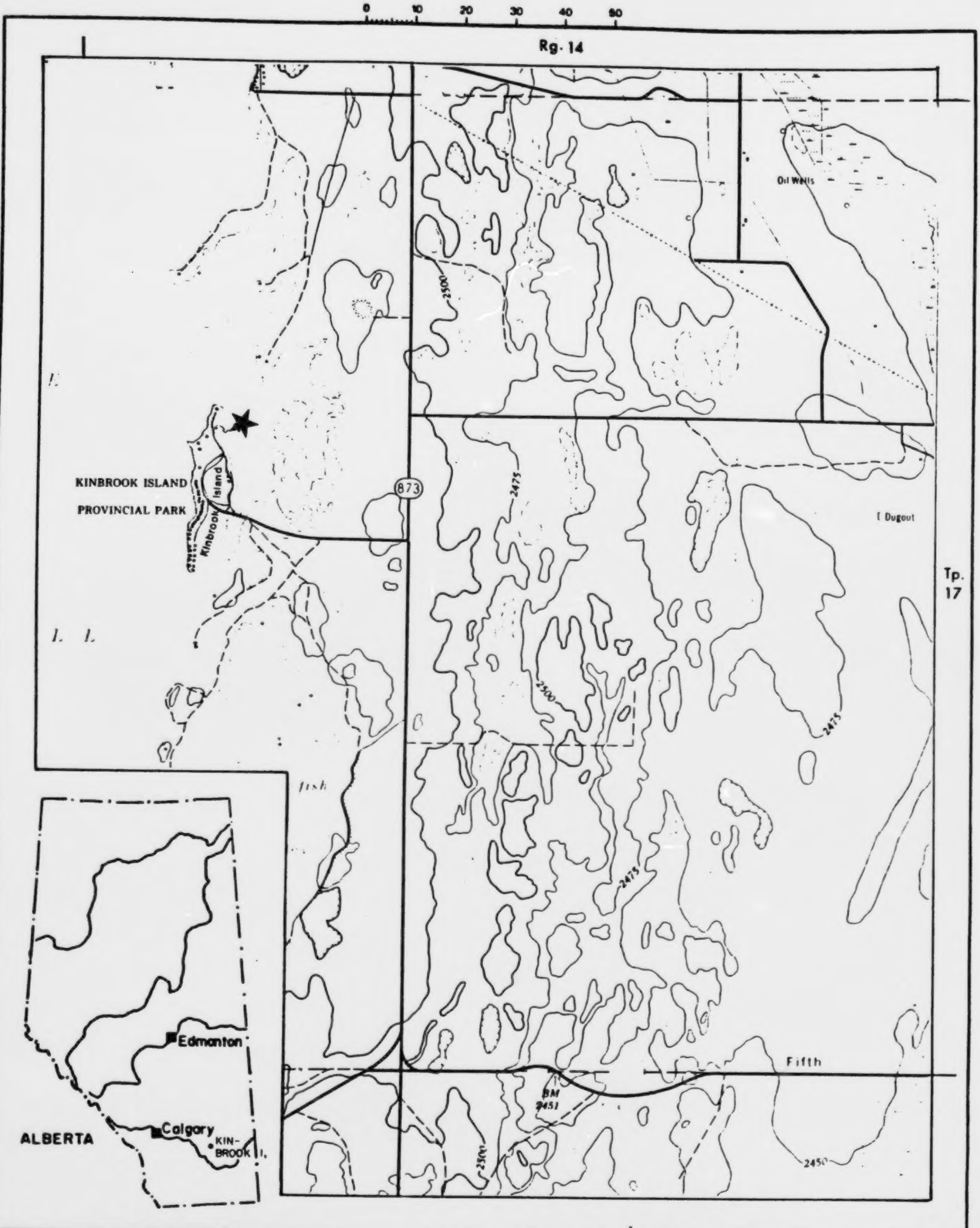
FIELD PROGRAM

- will commence if and when the lake water overlying the site freezes to the bottom;
- estimate drilling will commence at this location in February 1986.

MICROFILM DATE

DRAWING No

FILE No



0
10
20
30
40
50
Rg. 14
Oil Wells
2500
KINBROOK ISLAND
PROVINCIAL PARK
Kinbrook Island
873
2475
I Dugout
Tp. 17
2500
2475
fish
2475
Fifth
BM 2451
2500
2450
ALBERTA
Edmonton
Calgary
KIN-BROOK I.

Alberta
ENVIRONMENT

SUBMITTED W. L. Arvin DATE Feb. 14/86	DESIGNED CHECKED
APPROVED DATE Feb 14/86	DRAWN CHECKED

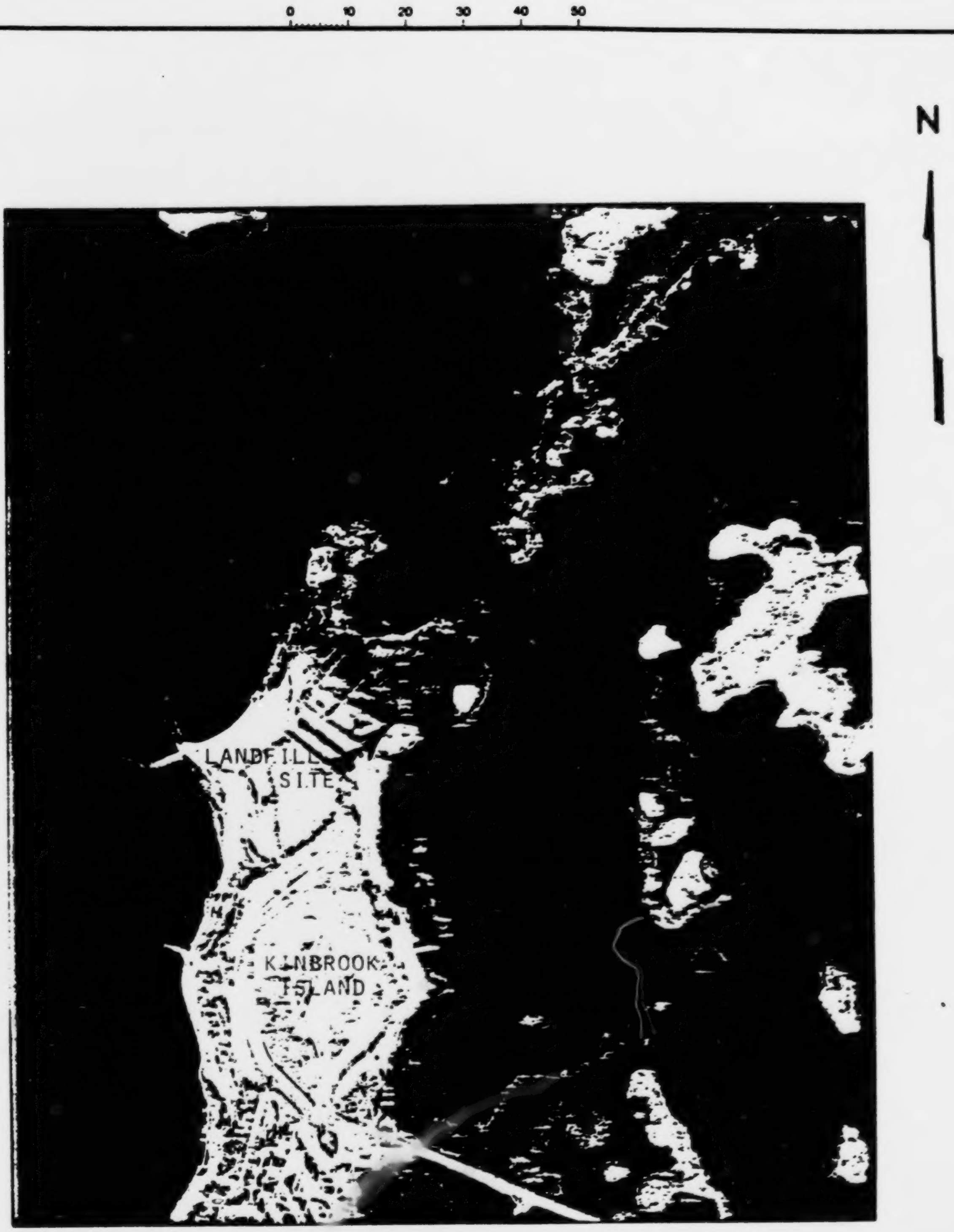
KINBROOK ISLAND RECLAIMED LANDFILL

LOCATION PLAN

SCALE 1=50000	SHEET OF
DATE	FIGURE No. 1

MICROFILM DATE

DRAWING No


0
10
20
30
40
50
N
LANDFILL SITE
KINBROOK ISLAND

Alberta ENVIRONMENT

SUBMITTED
DATE Feb. 14 86

DESIGNED R.M.C.
CHECKED

APPROVED R.M. Cracken
DATE Feb. 14 86

DRAWN
CHECKED

Modified Landfill Investigation

Brooks Area - County of Newell #4

Pt. N.E. 19-17-14-W4

Kinbrook Island Provincial Park Landfill

SCALE 1:10 000

SHEET OF

DATE November 1985

FIGURE No. 2

FILE No

LINDEN RECLAIMED LANDFILL

SE 20-30-25-W4

LOCATION AND SITE DESCRIPTION

- the site, approximately 1.2 ac (0.5 ha) in area, is located approximately 1.5 km southeast of Linden on a slope overlooking the Kneehill Creek valley;
- it has a relief of approximately 10 m;
- it was reclaimed and until recently has been used as part of a rural residence.

FIELD PROGRAM

Test Drilling and Monitor Completion

- three testholes were drilled (location shown in Figure 2 and borehole logs attached);
- three water table wells were installed (completion details in Table 1).

Monitoring

- water levels were recorded on July 9, 1985 (Table 2);
- groundwater samples were collected for chemical analysis from one water well and three domestic wells on November 5, 1985 (Table 3);
- two surface water samples were collected from Kneehill Creek at the same time.

EM Survey

- terrain conductvitiy surveys were conducted using the EM-31 instrument in the vertical mode (approximate depth of 3 m) and in the horizontal mode (approximate depth of 6 m);
- location of measurement points, conductivity values and contour lines are shown in Figures 3 and 4.

STUDY RESULTS

Geology

- layers of silt, clay and till overlie grey shale. A 1 m thick sand lens was encountered at the southeast corner of the site at 4.5 m depth. Depth to bedrock varies from more than 12 m in the northeast corner (high elevation) to 9 m in the southeast (low elevation).

Hydrogeology

- shallow groundwater flow is to the southwest toward the Kneehill Creek;
- the depth to the water table is approximately 10 m;
- hydraulic conductivity of both surficial and shallow bedrock material is low (i.e., $<10^{-6}$ cm/s).

EM Survey Results

- terrain conductivity values and resulting contour lines are shown in Figures 4 and 5;
- background values are approximately 8 and 15 mS/cm, for the 3 m and the 6 m depth, respectively;
- the refuse area is characterized by high conductivity values;
- the shallower (3 m) of the two surveys resulted in higher conductivity values indicating shallow depth of the buried refuse.

Groundwater Chemistry

- upgradient groundwater is predominantly the calcium-magnesium/bicarbonate type with a total dissolved solids concentration of less than 500 mg/L. Upper limits of Canadian Drinking Water Standards are not exceeded;
- none of the water samples analysed showed elevated concentration of chlorides and iron or high organic contents which are the dominant indicators of leachate contamination.

CONCLUSION

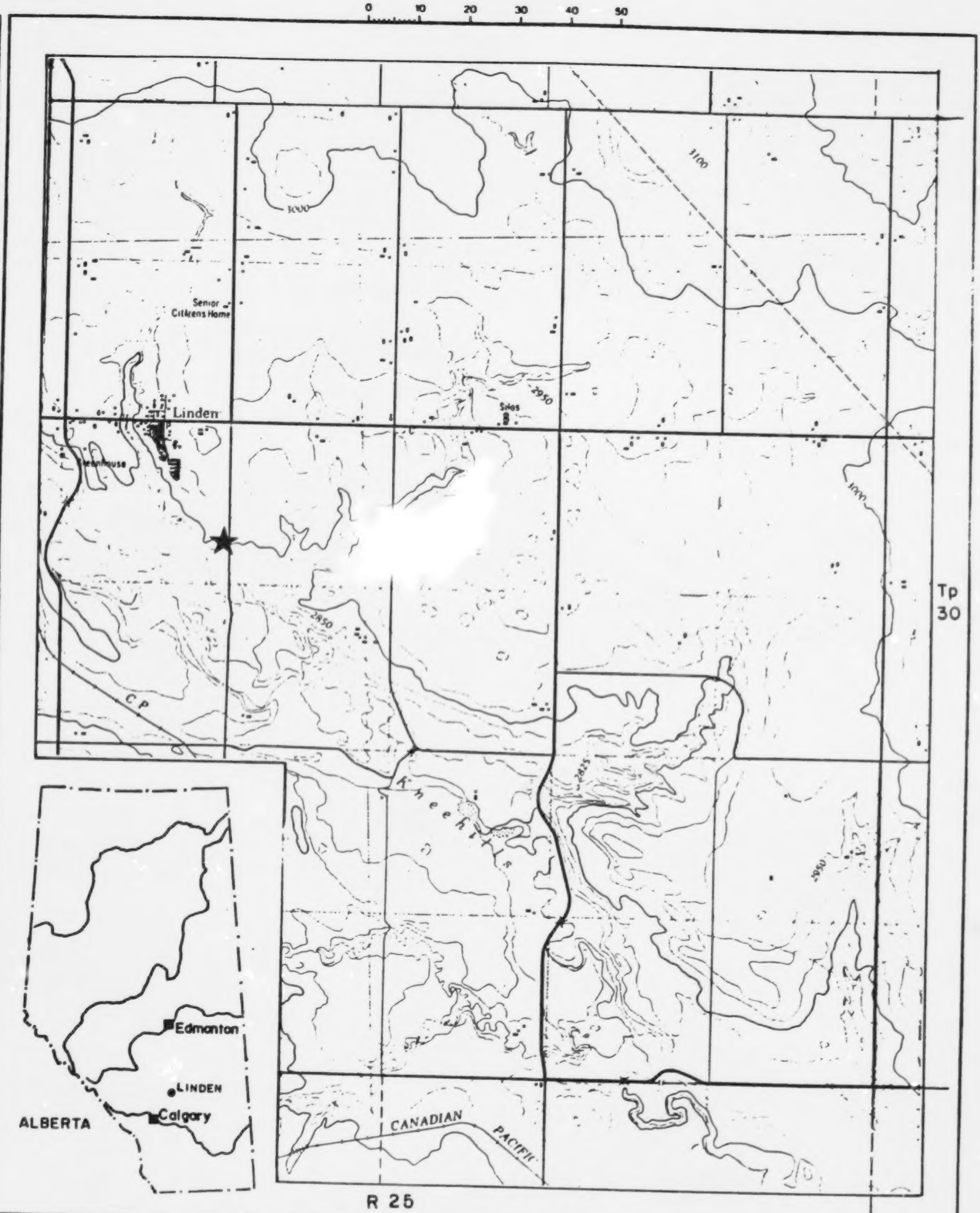
- the refuse is deposited in low permeably material above the water table;
- no leachate contamination was found in the shallow groundwater, domestic well water, or nearby surface water;
- shallow groundwater down gradient from the site, in view of the low permeable material encountered during the drilling of two dry wells, is expected to be only minimally affected by leachate contamination.

RECOMMENDATION

- monitoring to be discontinued and priority level of the site to be down graded.

MICROFILM DATE

DRAWING No


0
10
20
30
40
50
3000
3100
Senior Citizens Home
Linden
Silos
2950
Greenhouse
3000
Tp 30
2850
CP
2825
Kneehills
2950
CANADIAN
PACIFIC
Edmonton
LINDEN
ALBERTA
Calgary
R 25

Alberta
ENVIRONMENT

SUBMITTED W. J.
DATE Feb. 14 '86
APPROVED J. McCracken
DATE Feb. 14/86

DESIGNED
CHECKED
DRAWN
CHECKED

FILE No

LINDEN RECLAIMED LANDFILL

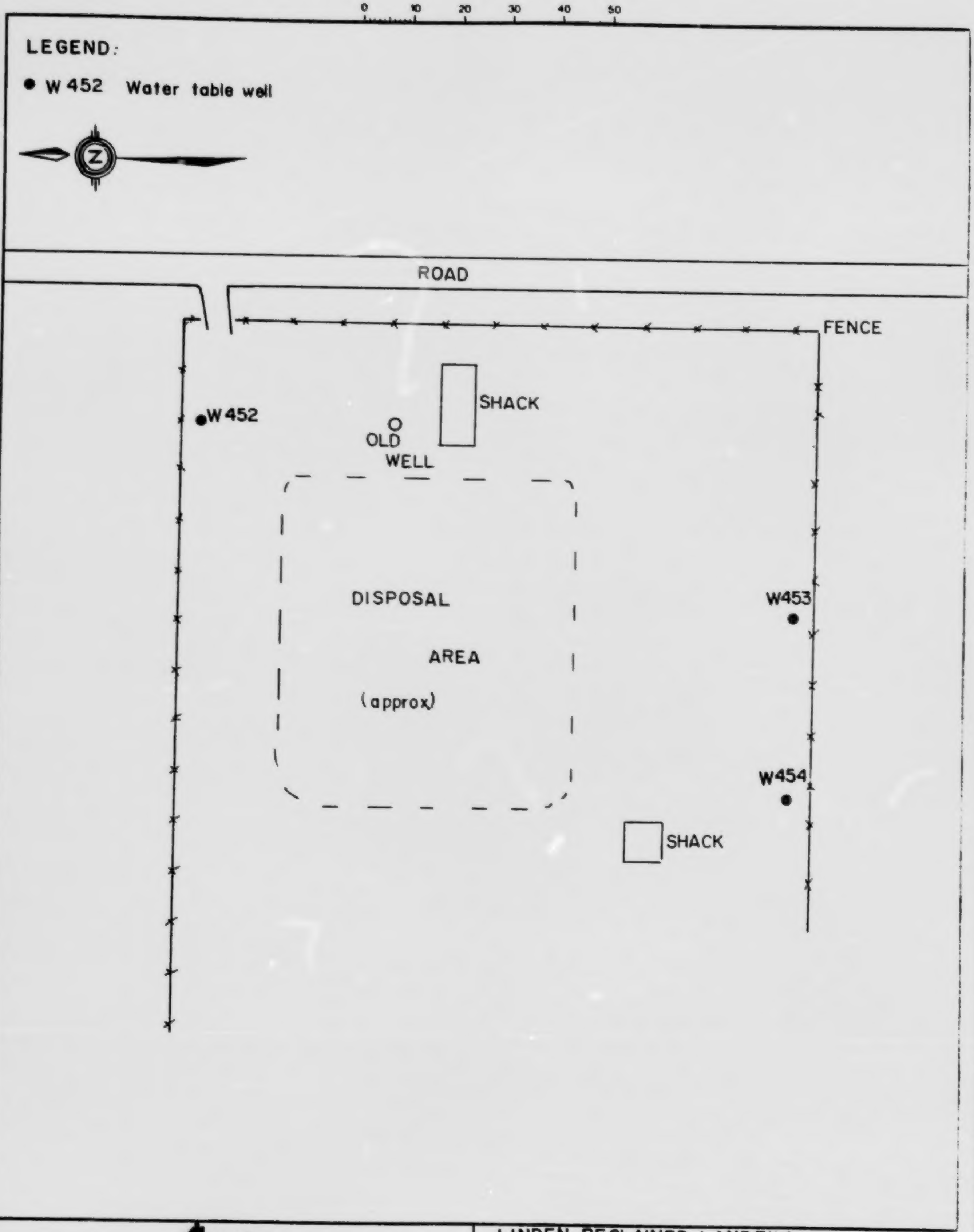
LOCATION PLAN

SCALE 1:50000
DATE
SHEET OF
FIGURE No. 1

MICROFILM DATE

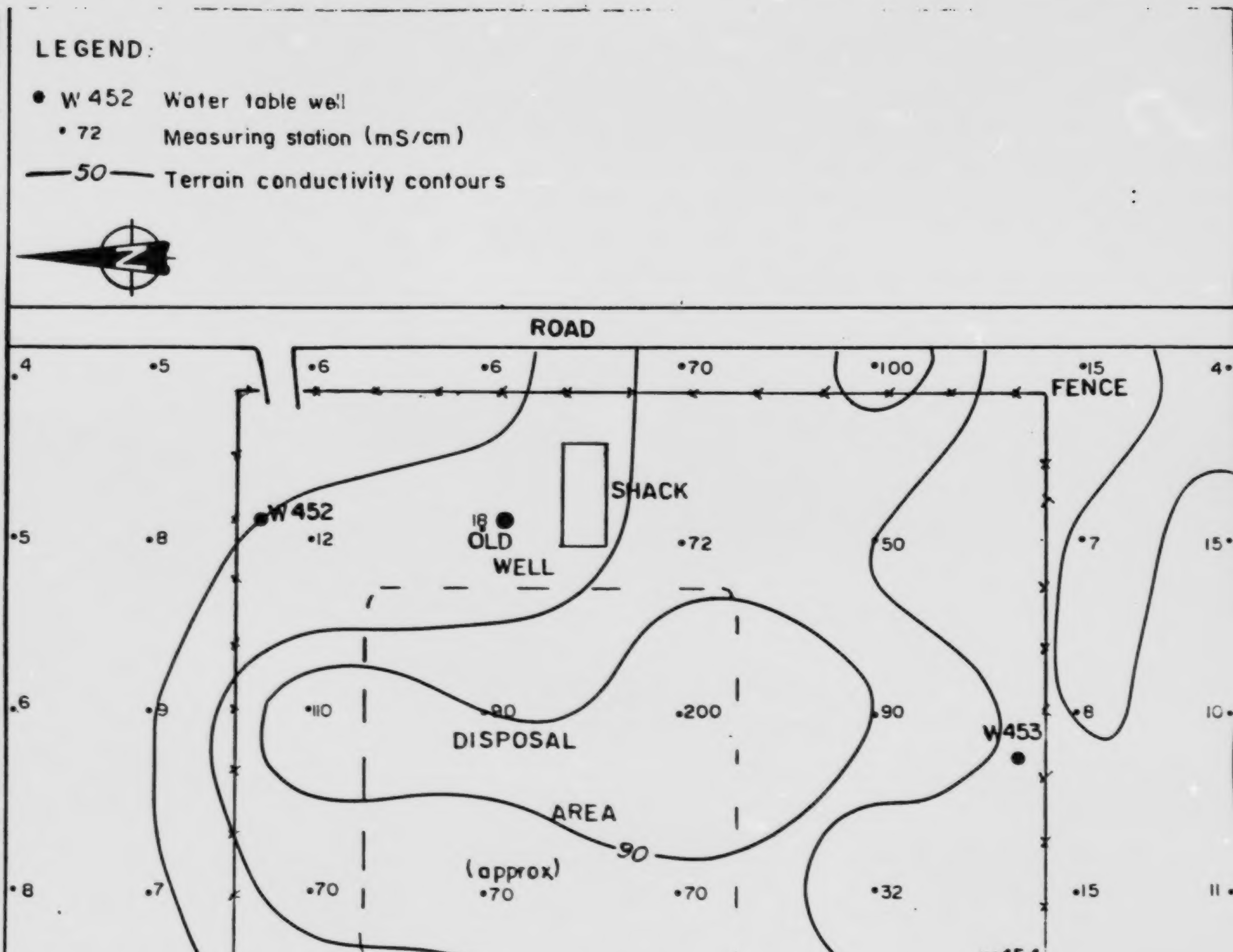
DRAWING No

FILE No.


0
10
20
30
40
50
LEGEND:
● W 452 Water table well
Z
ROAD
FENCE
W 452
SHACK
O
OLD
WELL
DISPOSAL
AREA
(approx)
W453
W454
SHACK

Alberta
ENVIRONMENT

SUBMITTED	DESIGNED W.C.	LINDEN RECLAIMED LANDFILL
DATE Feb. 14/86	CHECKED	SITE PLAN
APPROVED L. McCracken	DRAWN M.D.	SCALE not to scale / SHEET OF
DATE Feb 14/86	CHECKED	DATE / FIGURE No. 2


LEGEND:
● W 452 Water table well
• 72 Measuring station (mS/cm)
—50— Terrain conductivity contours
N
ROAD
FENCE
SHACK
W452
18 OLD WELL
DISPOSAL AREA (approx)
W453
W454
SHACK
90
50
10
4
5
6
6
70
100
15
4
5
8
12
72
50
7
15
6
9
110
90
200
90
8
10
8
7
70
70
70
32
15
11
8
6
10
33
60
55
12
10
8
7
8
18
7
6
4
6
7
4
5

MICROFILM DATE

DRAWING No

FILE No

Alberta
ENVIRONMENT

SUBMITTED
DATE Feb. 14/86

APPROVED
DATE Feb. 14/86

DESIGNED W.C.
CHECKED

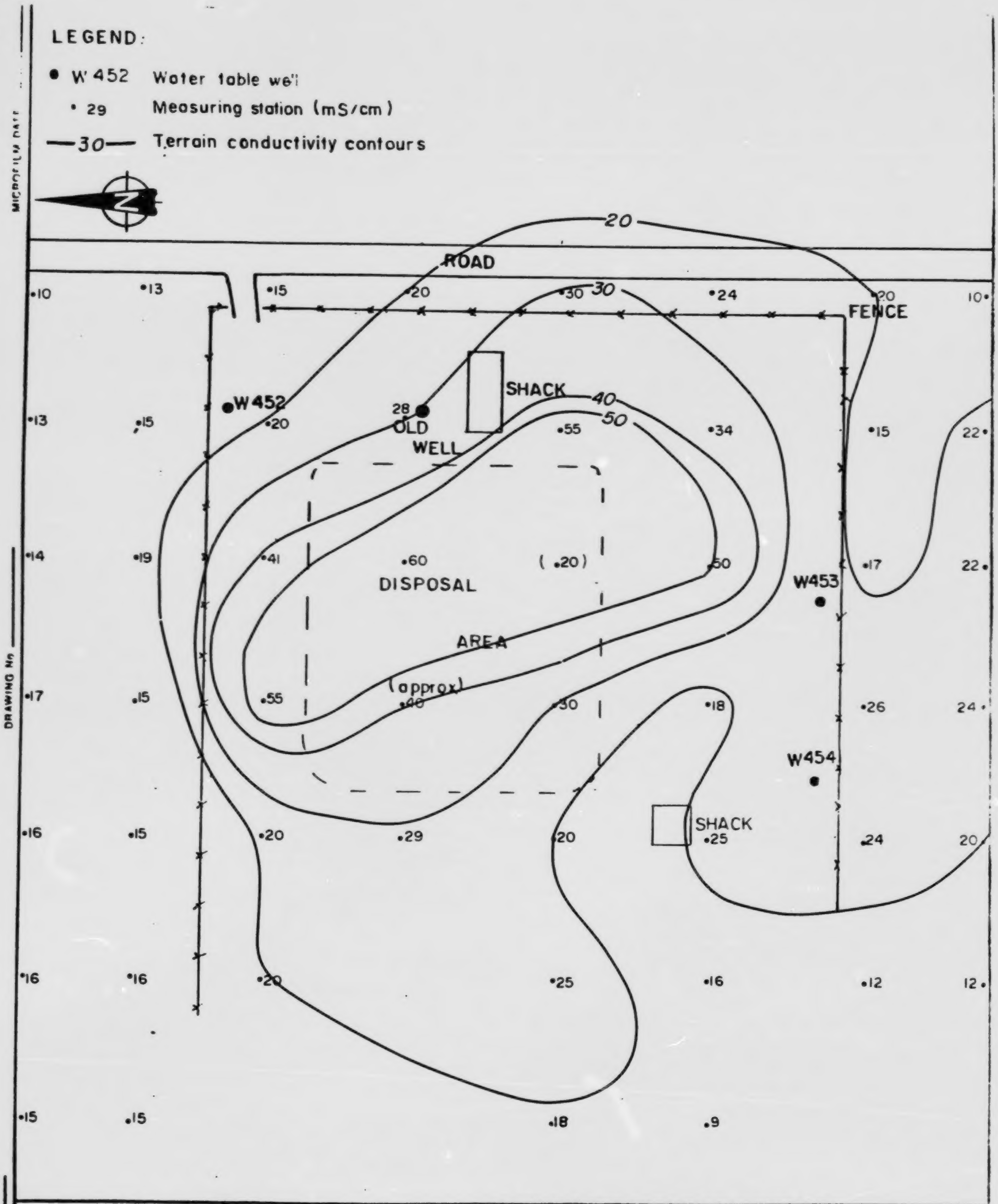
DRAWN M.D.
CHECKED

LINDEN RECLAIMED LANDFILL

TERRAIN CONDUCTIVTY
approx. 3 m below ground level

SCALE not to scale
DATE

SHEET OF
FIGURE No.3


LEGEND:
W 452 Water table well
29 Measuring station (mS/cm)
30 Terrain conductivity contours
N
ROAD
FENCE
SHACK
OLD WELL
W452
W453
W454
DISPOSAL AREA (approx)
SHACK
20
30
40
50
10
13
15
20
30
24
20
10
13
15
20
28
55
34
15
22
14
19
41
60
(20)
50
17
22
17
15
55
40
30
18
26
24
16
15
20
29
20
25
24
20
16
16
20
25
16
12
12
15
15
18
9

LINDEN RECLAIMED LANDFILL

TERRAIN CONDUCTIVTY
approx. 6 m below ground level

Alberta ENVIRONMENT

SUBMITTED	DESIGNED W.C.
DATE Feb. 14 /86	CHECKED
APPROVED	DRAWN M.D.
DATE Feb. 14/86	CHECKED

SCALE not to scale	SHEET OF
DATE	FIGURE No. 4

TABLE 1: MONITORING WELL COMPLETION INFORMATION

Well Number	Date Installed	Well Depth (m)	Screened interval (m)	Elevation of pipe (m)
452	27 8 85	12	6 - 12	50
453	27 8 85	9	3 - 9	50
454	27 8 85	10	4 - 10	50

TABLE 2: WATER LEVEL DATA

Well Number	Water Level Depth (b.g.l.) (m)
452	8.02
453	<9
454	<10

TABLE 3: WATER ANALYSIS RESULTS

	Well Numbers						C.D.W.S.*
	W452	Old Well	South Farm Well	Creek	Creek	East Farm Well	
LAB DATA							
pH	7.29	8.13	8.39	8.46	8.32	8.6	
EC (mS/cm)	.57	3.34	2.15	1.11	1.13	1.52	
SAR	.3	45.3	42.8	3.6	3.6	11.8	
LAB ANALYSIS							
(all parameters in mg/L)							
Inorganic							
Ca	86	18	8	55	59	36	NE**
Mg	27.6	2.4	1.2	40.8	39.6	10.8	150
Ca/CO_3(T.Hard)	330.0	55.0	25.0	307.5	312.5	135.0	500
Na	11.5	776.2	494.3	145.5	145.5	316.5	300
K	1.96	1.17	.78	14.86	13.29	2.74	NE
HCO_3	414.19	910.12	588.65	488.00	499.59	633.79	NE
$CaCO_3$(T.Alk)	340	746	482	400	409	520	500
SO_4	19.2	998.4	604.8	199.2	216	316	500
Cl	3.55	10.64	5.32	14.18	13.29	4.43	250
NO_3-N+NO_2-N	.21	.14	<.07	.07	.07	.14	10
NH_4-N	.07	.56	.07	.14	.21	.70	.5
TDS	355	2252	1412	725	470	999	1000
Organic							
COD	<1	5	3	43	34	5	
Metals							
Fe	.09	.15	.26	.10	.10	.20	.3
Mn	.30	.09	.02	.02	.04	.07	.05
Cu	.01	.01	.01	.01	.01	.01	1.0
Zn	.02	1.51	.01	.01	.01	.01	5.0
Pb	.04	.04	.04	.04	.04	.04	.05

* Canadian Drinking Water Standards

** Not Established

SOILS BRANCH DRILL HOLE LOG

Land Location SE Sec. 20 Tp. 30 R. 25 W. 4

Date August 27, 1985 Supervisor W. Ceroici

Project Linden Reclaimed Landfill

Test Hole 452 to 454 inclusive.

Test Hole 452

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - .5	topsoil, dark brown, silty clay	d
.5 - 1.5	silty clay, light brown, lacustrine	d
1.5 - 6	till, brown, firm, silty	sm - m
6 - 9	till, brown, plastic, silty	s
9 - 12	till, brown, very plastic, silty	s

installation: watertable well 12 m deep, slotted 6 - 12 m, 2" PVC pipe

Test Hole #453

0 - .5	topsoil, black-brown, silty	d
.5 - 4	silt, brown, lacustrine	d - sm
4 - 5	silt, brown, with layers of grey clay	sm
5 - 7	till, dark brown, firm,	sm
7 - 9	till, brown, friable, pebbles	sm - d

installation: watertable well, 9 m deep, slotted 3 - 9 m, 2" PVC pipe

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole #454		
0 - .5	topsoil, black	d
.5 - 3	silt, light brown	d
3 - 4.5	silt, light brown	sm
4.5 - 5.5	sand, brown, fine grained, some clay	d
5.5 - 9	till, dark brown, pebbles, hard drilling	d
9 - 10	shale, grey, hard drilling	d

installation: watertable well, 10 m deep, slotted 4 - 10 m, 2" PVC pipe

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

MANOLA RECLAIMED LANDFILL

NE 16-59-2-W5

LOCATION AND SITE DESCRIPTION

- the site is located about 1 km north of Manola on the east bank of the Pembina River (Figure 1);
- the site, which has been reclaimed, slopes steeply to the west;
- a small gulley, cut into the slope, has exposed some refuse;
- mainly domestic refuse was reportedly disposed of at the site;
- the area of the disposal site is approximately 3 ac (1 ha).

FIELD PROGRAM

Test Drilling and Monitor Completion

- three testholes were drilled (locations shown in Figure 2 and borehole logs attached);
- two water table wells and a piezometer installed at three locations (completion details contained in borehole logs).

Monitoring

- groundwater samples were collected for chemical analysis on September 18, 1985 (Table 1);
- water levels were recorded on September 16, 1985;

Well Number	Water level, m (below ground level)
P449	dry @ 12
W450	4.5
W451	4.5

STUDY RESULTS

Geology

- till, containing fine-grained sand lenses, overlies shale-siltstone bedrock;
- the depth to bedrock in the landfill area is approximately 10.5 m.

Hydrogeology

- predominant direction of shallow groundwater flow is to the west toward the Pembina River;
- depth to water table is variable, from >12 m on top of the slope to 4.5 m at the bottom of the slope;
- the hydraulic conductivity of the till is estimated at 10^{-6} - 10^{-7} cm/s, based on visual analysis.

Hydrochemistry

- no background data available because P449, located upgradient from the landfill, was dry;
- shallow groundwater down-gradient from the site is the calcium-magnesium/bicarbonate type with a total dissolved solids concentration <1000 mg/L.
- only the iron concentration in groundwater from W450 and the manganese concentration in groundwater from W450 and W451 exceed Canadian Drinking Water Standards upper limits. Elevated concentrations of these metals in shallow groundwater is common in central Alberta;
- no organic contamination detected.

CONCLUSIONS

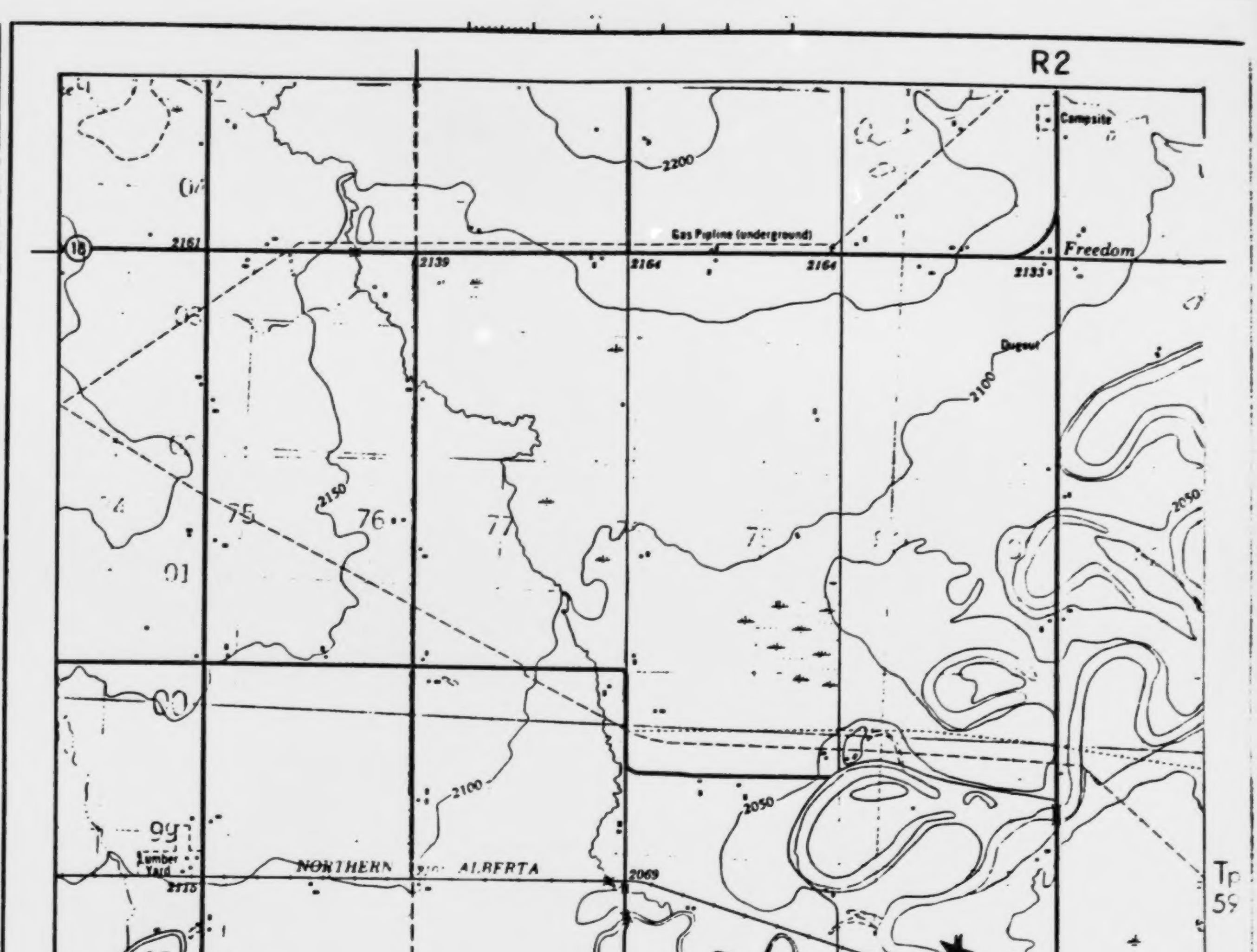
- the landfill is located in an area underlain by low permeability till;
- there is no evidence of groundwater contamination from the landfill;
- it is not expected that the landfill will pollute water in the Pembina River.

RECOMMENDATIONS

- monitoring at the site should be discontinued;
- the site should be downgraded to low priority.

MICROFILM DATE

DRAWING No.


R2
Campsite
2200
Gas Pipline (underground)
18
2161
2139
2164
2164
Freedom
2133
Dugout
2100
2150
75
76
77
2050
2100
2050
NORTHERN ALBERTA
Lumber Yard
2115
2069
Tp 59
Manola
5 Gas Tanks
Elevators
RIVER
2100
MANOLA
Edmonton
Calgary
ALBERTA

Alberta ENVIRONMENT

SUBMITTED	DESIGNED
DATE Feb. 14/86	CHECKED
APPROVED	DRAWN
DATE Feb. 14/86	CHECKED

MANOLA RECLAIMED LANDFILL

LOCATION PLAN

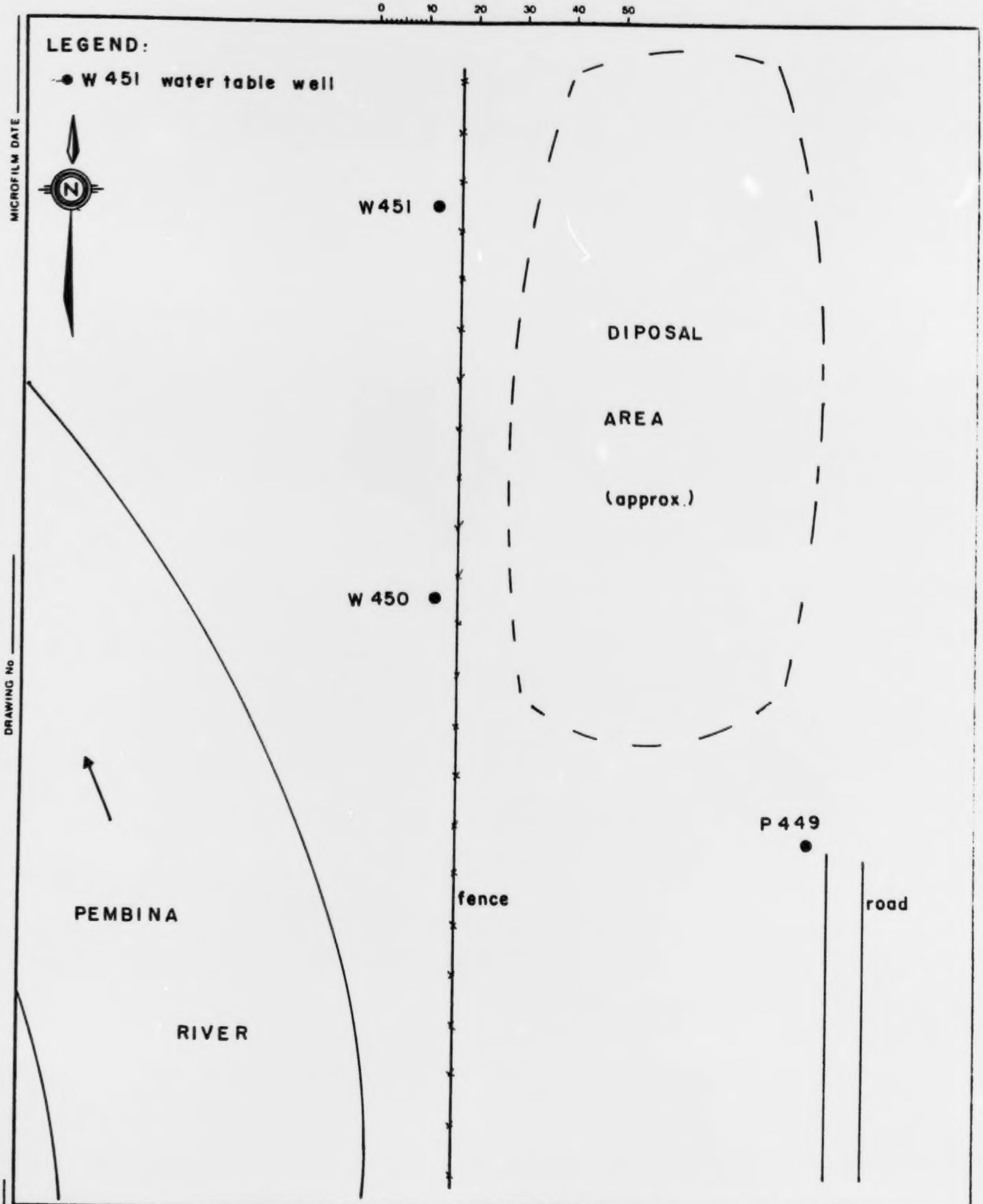
SCALE 1=50000

SHEET OF

DATE

FIGURE No. 1

FILE No.


0
10
20
30
40
50
LEGEND:
● W 451 water table well
N
W451
W 450
DIPOSAL
AREA
(approx.)
P 449
fence
road
PEMBINA
RIVER

MICROFILM DATE

DRAWING No

FILE No.

Alberta ENVIRONMENT

SUBMITTED
DATE Feb. 14/86
APPROVED
DATE Feb. 14/86

DESIGNED W.C.
CHECKED
DRAWN M.D.
CHECKED

MANOLA RECLAIMED LANDFILL

SITE PLAN

SCALE not to scale
DATE
SHEET OF
FIGURE No. 2

TABLE 1: Groundwater Chemistry Analyses

	Well Numbers		C.D.W.S.*
	W450	W451	
LAB ANALYSIS - all parameters in mg/L			
Inorganic			
Ca	116	110	NE**
Mg	25.2	30.6	150
K	4.3	4.5	NE
Na	34.7	80.9	300
Cl	4.4	5.3	250
SO_4	12	98	500
HCO_3	567	600	NE
NH_4-N	0.14	0.21	1
NO_3-N	0.07	0.07	10
Total Hard.	395	402	500
T.D.S.	475	624	1000
Metals			
Fe	0.8	0.05	0.3
Mn	0.49	0.25	0.05
Cu	<0.01	<0.01	1.0
Zn	0.05	0.04	5.0
Pb	0.01	0.01	0.05
Organics			
TOC	6.8	11.4	
TIC	115	119	
TC	121.8	130.4	
COD	27	30	
Other			
pH	8.1	8.2	
E.C. (mS/cm)	0.77	0.97	
S.A.R.	0.8	1.7	

* Canadian Drinking Water Standards
** Not Established

SOILS BRANCH DRILL HOLE LOG

Land Location NE Sec. 16 Tp. 59 R. 2 W. 5

Date August 26, 1985 Supervisor W. Ceroici

Project Manola Reclaimed Landfill

Test Hole 449 to 451 inclusive.

Test Hole 449

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - 2	clay, brown, fill	d
2 - 2.5	sand, brown, medium & coarse grained	d
2.5 - 4.5	till, brown, some oxidized streaks, pebbles and coal	sm - m
4.5 - 10.5	till, grey, plastic, few pebbles	m
10.5 - 12	shale, grey, soft, with siltstone interbeds	s

installation: piezometer, 12 m deep, 3 m slotted screen, 2" PVC pipe

Test Hole #450

0 - 1.5	sand, brown, fine grained	d
1.5 - 3	sand, brown, more clayey	m
3 - 4	till, grey, oxidized streaks, fine grained sand lenses	m
4 - 6	till, grey, plastic	vm - s

installation: watertable well, 6 m deep, slotted 3 - 6 m below ground level

Test Hole #451

0 - 0.5	topsoil, clayey	d
0.5 - 1.5	clay, brown, sandy	d
1.5 - 3	till, brown, sandy	sm
3 - 6	till, brown, rust streaks, plastic	vm - s

installation: watertable well, 6 m deep, slotted 3 - 6 m b.g.l.

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

MINBURN LANDFILL

SW 14-50-10-W4

LOCATION AND SITE DESCRIPTION

- the landfill site is located about 0.5 km southeast of Minburn (Figure 1) on the side of a hill overlooking the village;
- the area has sand at the surface;
- primarily domestic refuse is disposed of at the site;
- the disposal site has an area of approximately 2.5 ac (1 ha).

FIELD WORK

Test Drilling and Monitor Installation

- seven testholes were completed at six sites (locations shown on Figure 2 and borehole logs attached);
- five water table wells and a piezometer were completed (completion data contained in Table 1).

Monitoring

- water levels recorded on September 5, 1985 (Table 2);
- groundwater samples were collected for chemical analysis on September 11, 1985 (Table 3).

EM Survey

- a terrain conductivity survey was conducted using the EM-31 in the vertical mode (approximate 3 m depth) and in the horizontal mode (approximate 6 m depth;
- six transects were completed (Figure 3 and 4).

STUDY RESULTS

Geology

- the surficial materials consist of fine to medium grained sand overlying till;
- silty clay lenses are interspersed through the sand;
- at one location the sand was found to be greater than 9 m in thickness.

Hydrogeology

- the depth to the water table is between 4 and 7 m in the landfill area;
- the predominant direction of shallow groundwater flow is toward the north-northwest under the influence of a horizontal hydraulic gradient of 0.06 (Figure 5);
- the hydraulic conductivity of the sand is estimated to vary between 10^{-3} and 10^{-5} cm/s.

EM Survey

- conductivity values from the 3 m depth (Figure 3) in the landfill area slightly exceed background values (i.e., <5 mS/cm). In general, the response is poor possibly because the water table depth (i.e. 4 to 7 m) is greater than the depth of penetration;
- at the 6 m depth (Figure 4) background conductivity values are generally less than 10 mS/cm. Conductivity values are highest in the landfill area, tending to decrease to the north-northwest, in the direction of groundwater flow;
- the low conductivity values suggest that, at least to the 6 m depth, the level of groundwater contamination is low.

Groundwater Chemistry

- groundwater from W404 and W405, located up-gradient from the landfill, indicates that background water is the calcium/magnesium-bicarbonate type with a total dissolved solids concentration generally less than 300 mg/L. Only the manganese concentration exceeds the upper limit for Canadian Drinking Water Standards;
- with the exception of groundwater from W407, groundwater from down-gradient wells tends to be slightly more mineralized than background indicating some contamination by leachate. However, the level of contamination is low, since only the ammonium and manganese concentration exceed Canadian Drinking Water Standards.
- groundwater from W407 is of poor quality, possibly since the well is located adjacent to reclaimed landfill cells;

- the source of the apparently high organic load in groundwater from P409 is uncertain. It is unusual that the organic load in groundwater from W410, completed at the same location but at a shallower depth, is substantially lower.

CONCLUSIONS

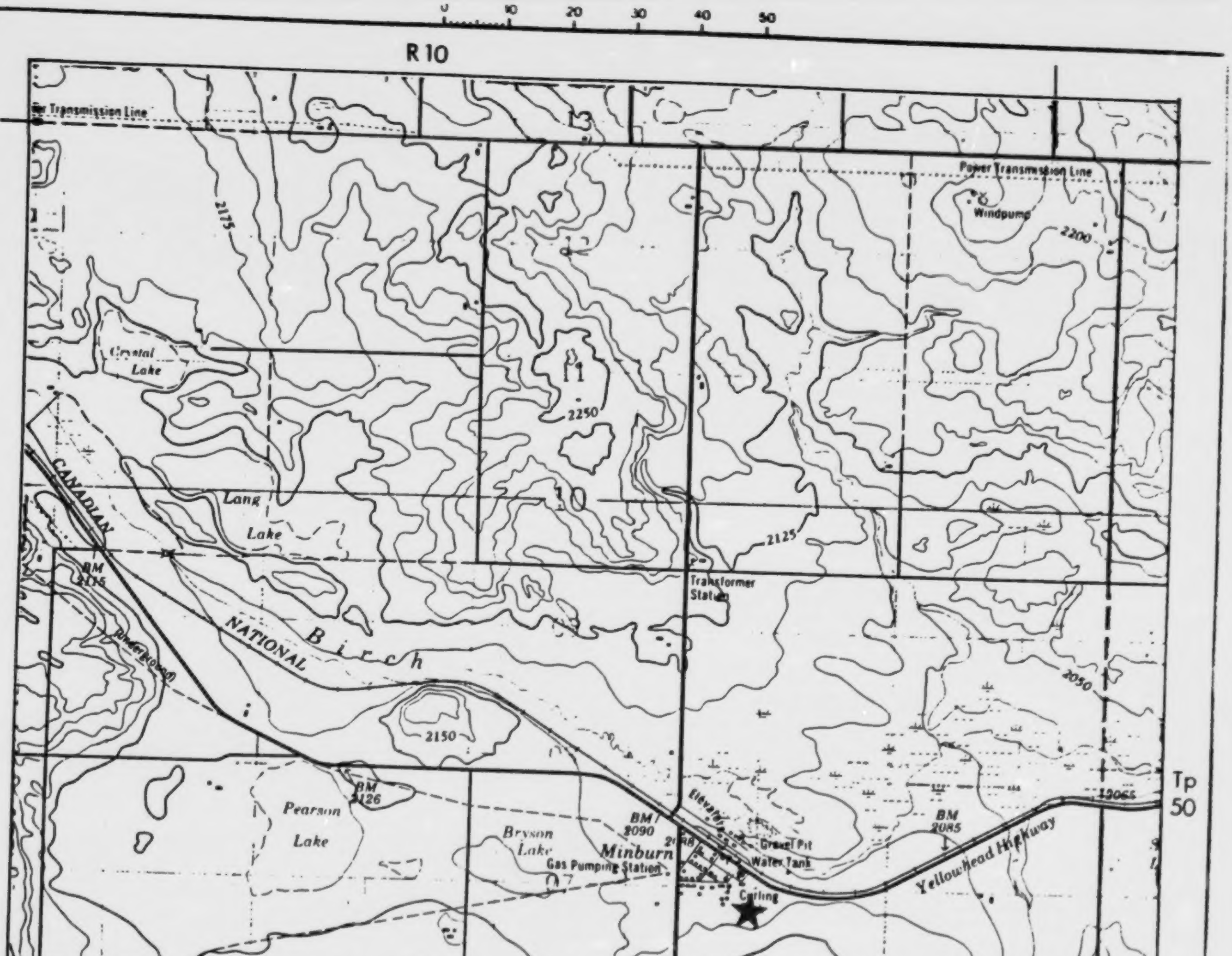
- the landfill has had minimal impact on shallow groundwater quality. The absence of significant groundwater contamination at the site may be attributable to an active shallow groundwater system which tends to reduce contaminant concentrations by dilution.

RECOMMENDATIONS

- a replicate groundwater sample will be collected from P409 to confirm the high organic content and possibly identify specific organic compounds;
- the landfill does not meet present landfill siting criteria primarily due to the presence of permeable sand deposits. It is recommended that the site no longer be used for waste disposal or at the very least disposal be limited to inert materials;
- it is recommended that the site be down graded to a lower priority since little groundwater contamination has occurred.

MICROFILM DATE

DRAWING No


0
10
20
30
40
50
R 10
Transmission Line
Power Transmission Line
Windpump
2200
2175
Crystal Lake
13
12
11
2250
10
2125
Long Lake
CANADIAN
NATIONAL
Birch
BM 2115
Transformer Station
2150
2050
Tp 50
BM 2126
Pearson Lake
Bryson Lake
BM 2090
Minburn
Elevator
Gravel Pit
Water Tank
Gas Pumping Station
07
Curling
BM 2085
Yellowhead Highway
Cemetery
06
05
04
2275
Windpump
ALBERTA
Edmonton
MINBURN
Calgary
R 10

Alberta
ENVIRONMENT

SUBMITTED W. J. Aron
DATE Feb. 14/86

APPROVED
DATE Feb. 14/86

DESIGNED
CHECKED

DRAWN
CHECKED

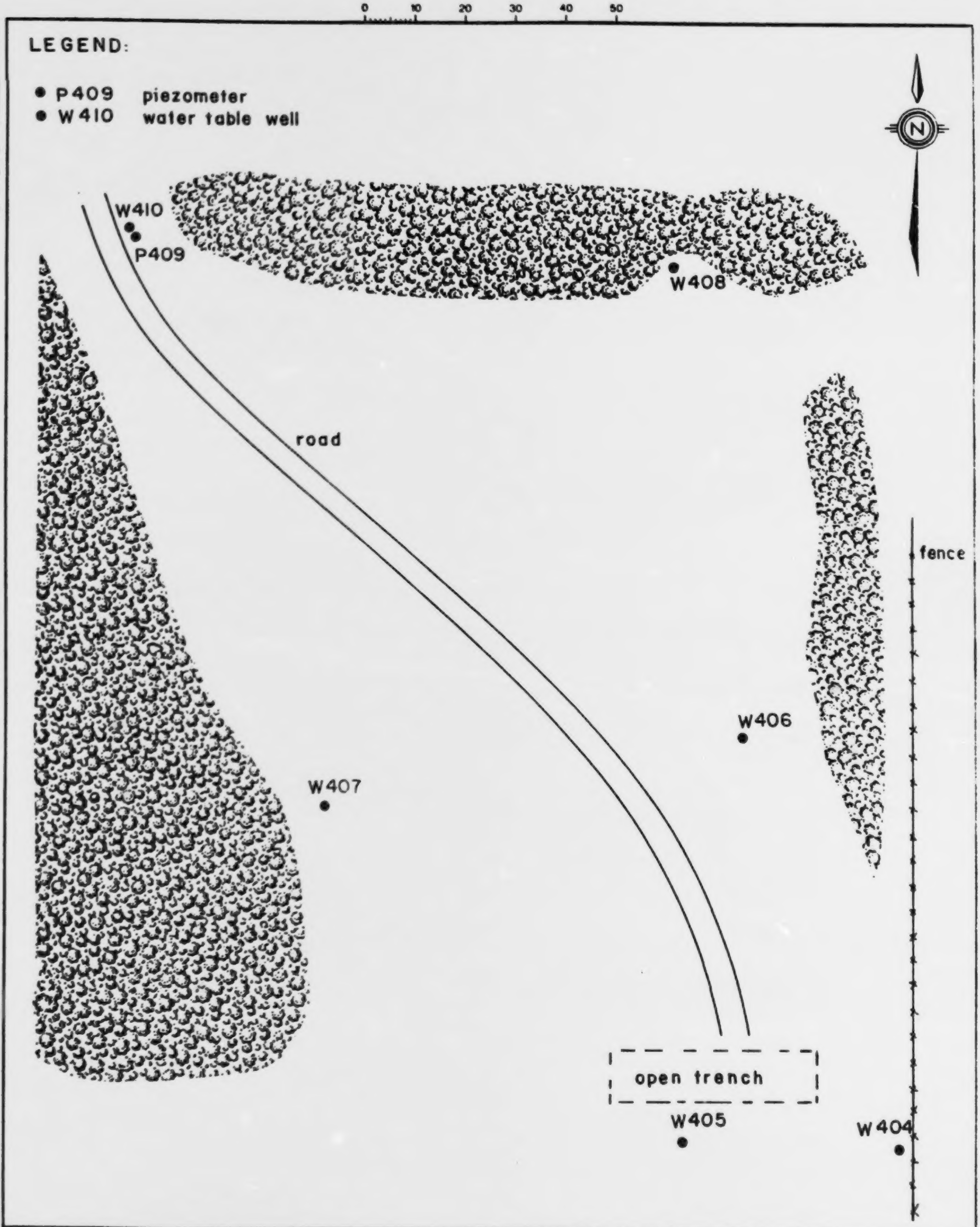
MINBURN LANDFILL

LOCATION PLAN

SCALE 1 = 50000
DATE

SHEET OF
FIGURE No. 1

FILE No.


0
10
20
30
40
50
LEGEND:
● P409 piezometer
● W410 water table well
N
W410
P409
W408
road
fence
W406
W407
open trench
W405
W404

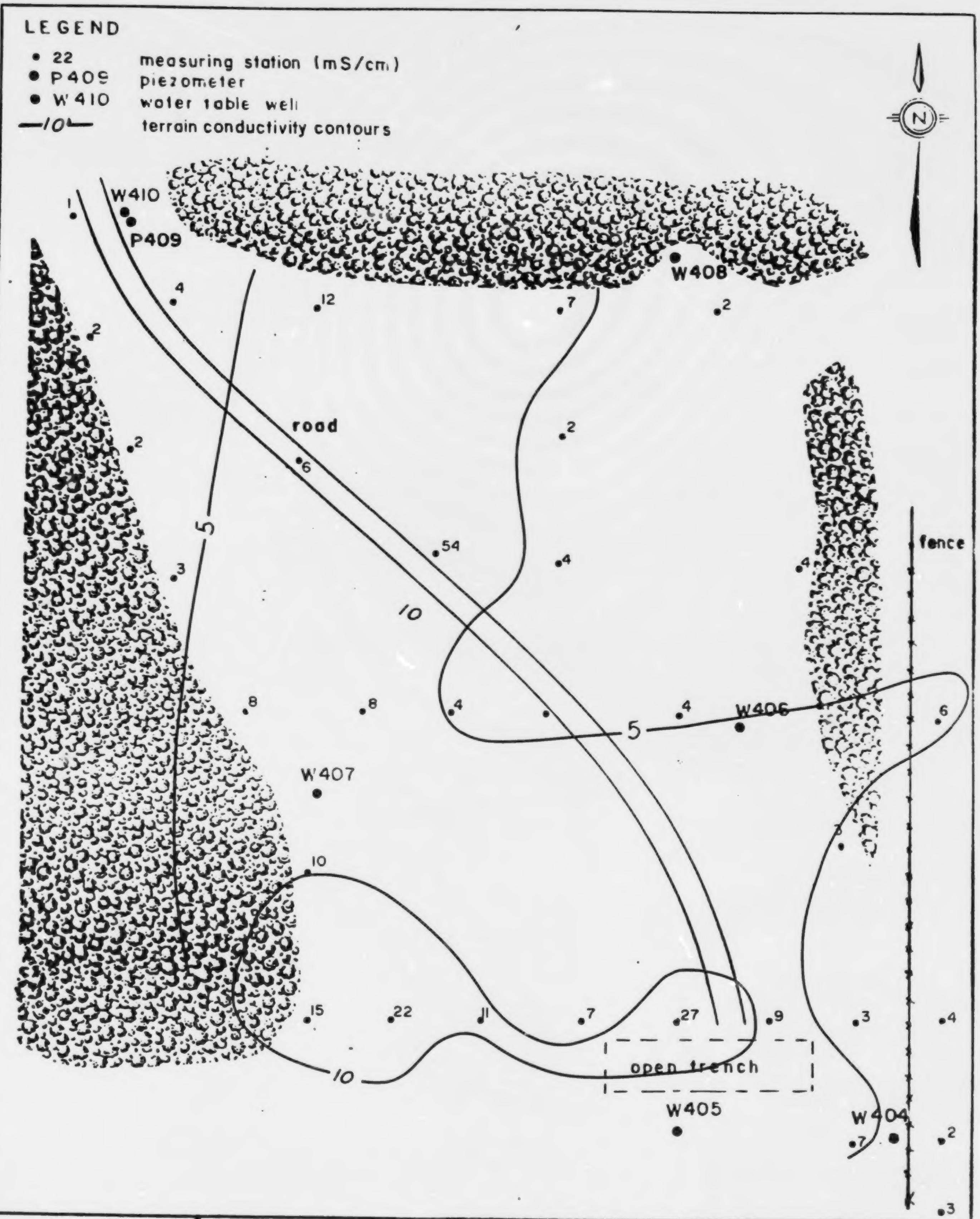
MICROFILM DATE

DRAWING No.

FILE No.

Alberta
ENVIRONMENT

SUBMITTED W. J. Aroi DATE Feb. 14/86	DESIGNED MD. CHECKED	MINBURN LANDFILL SITE PLAN
APPROVED McCracken DATE Feb. 14/86	DRAWN M.D. CHECKED	SCALE 1= 1000 DATE
		SHEET OF FIGURE No. 2


LEGEND
• 22 measuring station (mS/cm)
● P409 piezometer
● W410 water table well
—10— terrain conductivity contours
N
W410
P409
W408
W407
W406
W405
W404
road
fence
open trench
5
10
1
4
12
7
2
2
2
6
54
4
4
3
8
8
4
4
6
10
15
22
11
7
27
9
3
4
7
2
3

Alberta
ENVIRONMENT

SUBMITTED W. J. Lewis
DATE Feb. 14/86
APPROVED
DATE Feb 14/86
DESIGNED M.D.
CHECKED
DRAWN M.D.
CHECKED

MINBURN LANDFILL

TERRAIN CONDUCTIVITY

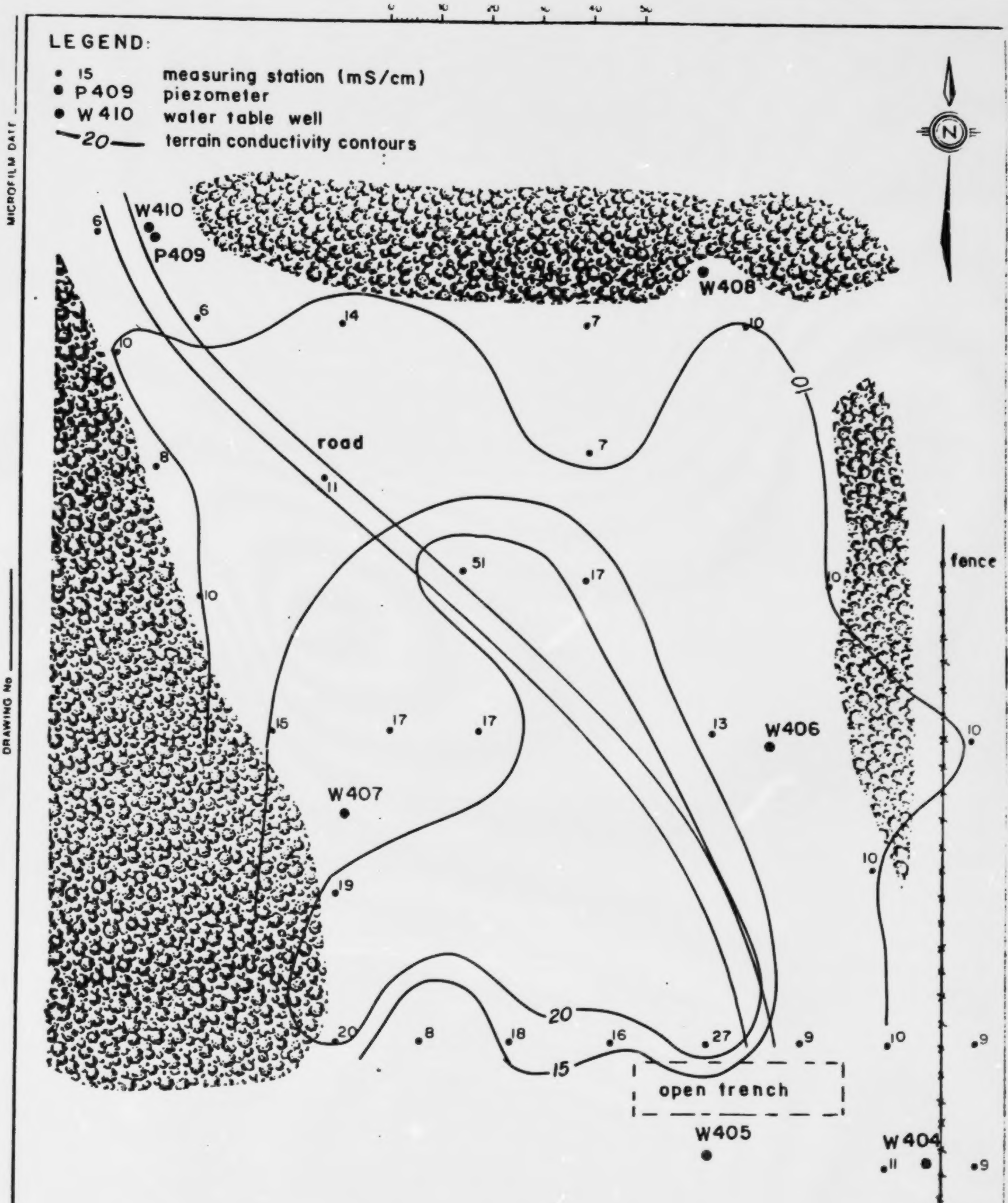
approx. 3 m below ground level

SCALE 1= 1000
DATE
SHEET OF
FIGURE No. 3

MICROFILM DATE
DRAWING No
FILE No

MICROFILM DATE

DRAWING No


0
10
20
30
40
50
LEGEND:
• 15 measuring station (mS/cm)
● P409 piezometer
● W410 water table well
—20— terrain conductivity contours
N
W410
P409
W408
W407
W406
W405
W404
road
fence
open trench
6
6
14
7
10
10
7
8
11
51
17
10
10
15
17
17
13
10
10
19
20
8
18
16
27
9
10
9
11
9
12
20
15
10

FILE No

Alberta
ENVIRONMENT

SUBMITTED W. J.
DATE Feb. 14/86
APPROVED J. McCracken
DATE Feb. 14/86

DESIGNED M.D.
CHECKED
DRAWN M.D.
CHECKED

MINBURN LANDFILL

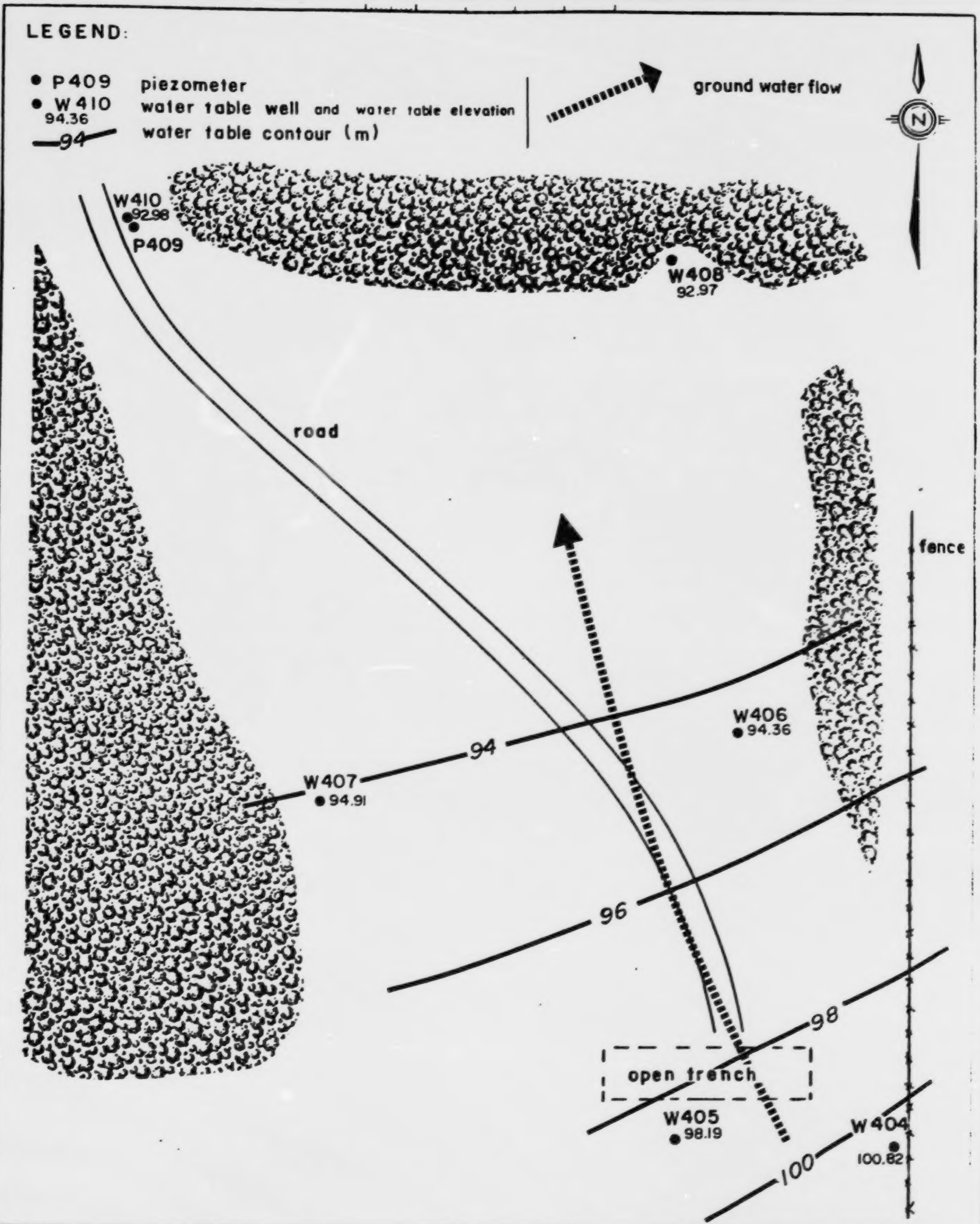
TERRAIN CONDUCTIVITY

approx. 6 m below ground level

SCALE 1= 1000
DATE
SHEET OF
FIGURE No. 4

MICROFILM DATE

DRAWING No


LEGEND:
● P409 piezometer
● W410 94.36 water table well and water table elevation
94 water table contour (m)
ground water flow
N
W410
92.98
P409
W408
92.97
road
fence
W406
94.36
94
W407
94.91
96
98
open trench
W405
98.19
W404
100.82
100

FILE No

Alberta
ENVIRONMENT

SUBMITTED
DATE Feb. 14/86

APPROVED
DATE Feb. 14/86

DESIGNED M.D.
CHECKED

DRAWN M.D.
CHECKED

MINBURN LANDFILL

WATER TABLE CONTOURS (m)

SCALE 1= 1000
DATE

SHEET OF
FIGURE No. 5

TABLE 1: MONITORING WELL COMPLETION

Well Number	Date Installed	Well Depth (m)	Height of pipe above ground surface (m)	Screened interval (m)	Ground elevation (m)	Elevation of pipe (m)	Pipe diameter (m)
W404	31 7 85	9	1	7 - 9	105.01	106.01	50
W405	31 7 85	10	1	5.5 - 10	103.21	104.21	50
W406	31 7 85	9	1	4.5 - 9	101.33	102.33	50
W407	31 7 85	10.5	1	6 - 10	100.41	101.41	50
W408	31 7 85	6	1	3 - 6	97.92	98.92	50
P409	31 7 85	7.5	1	7.1 - 7.5	96.95	97.95	50
W410	31 7 85	5	1	2 - 5	96.83	97.83	50

TABLE 2: WATER LEVEL DATA (85 09 05)

Well Number	Water Level Depth (b.g.l.) (m)	Elevation (m)
W404	4.19	100.82
W405	5.02	98.19
W406	6.97	94.36
W407	6.40	94.01
W408	5.35	92.57
P409	3.60	93.35
W410	3.87	92.96

TABLE 3: CHEMICAL ANALYSIS RESULTS

	Well Numbers							C.D.W.S.*
	W404	W405	W406	W407	W408	P409	W410	
FIELD DATA								
EC (mS/cm)	0.45	0.5	0.55	1.25	0.5	0.7	0.93	
pH	6.8	6.1	6.7	6.6	6.7	6.7	6.6	
LAB DATA								
pH	7.8	7.8	8.0	7.8	7.5	7.9	7.7	
EC (mS/cm)	0.44	0.44	0.49	1.4	0.47	0.88	0.98	
SAR	0.32	0.18	0.3	0.28	0.31	0.3	0.52	
LAB ANALYSIS (all parameters in mg/L)								
Inorganic								
Ca	70	70	74	208	70	81	139	NE**
Mg	18	23	22	78	20	45	45	150
$CaCO_3$ (T.Hard)	250	270	275	845	260	390	535	500
Na	11.6	69	11.6	18.5	11.6	14	28	300
K	1.6	2	1.6	3	2	4.3	6	NE
HCO_3	320	327	298	385	287	443	561	NE
$CaCO_3$ (T.Alk)	263	268	245	316	236	363	454	500
SO_4	14.4	14.4	38.4	504	26.4	105	151	500
Cl	1.8	0.9	3.8	13.3	8.0	6.2	3.6	250
NO_3-N+NO_2-N	0.08	0.08	1.7	1.5	5.0	0.35	<0.07	10
NH_4-N	0.14	0.14	0.14	0.14	0.2	2.1	4.7	.5
TDS	236	279	310	1021	302	475	648	1000
Organic								
COD	12	6	18	14	24	406	54	
TOC	3.1	2.8	5	4.4	7.1	143	20.2	
TIC	66.9	68.3	65.2	78.4	62.1	74.6	110.5	
TC	70	71.1	70.2	82.8	69.2	217.6	130.7	
Metals								
Fe	0.02	0.02	0.03	0.01	0.01	0.05	0.02	.3
Mn	0.11	0.02	0.05	0.59	0.01	0.22	0.90	.05
Cu	<0.01	<0.01	<0.01	0.01	<0.01	0.01	0.01	1.0
Zn	0.01	0.01	0.01	0.01	0.01	0.02	0.01	5.0
Pb	0.02	0.03	0.03	0.04	0.02	0.03	0.03	.05

* Canadian Drinking Water Standards
** Not Established

SOILS BRANCH DRILL HOLE LOG

Land Location SW Sec. 14 Tp. 50 R. 10 W. 4

Date July, 31 1985 Supervisor W. Ceroici

Project Minburn Reclaimed Landfill

Test Hole 404 to 410 inclusive.

Test Hole 404

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - 1	sand, brown, fine grained	d
1 - 3	sand, brown, fine to medium grained, clayey, some oxidized streaks	d - sm
3 - 7.5	sand, brown, fine to medium grained, hard to losely packed	m - s
7.5 - 8	clay, brown, silty	s
8 - 9	till, grey, plastic, oxidized streaks	s

installation: watertable well, 9 m deep, slotted 7 - 9 m, 2" PVC pipe

Test Hole #405

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - 1	sand, grey brown, loose, fine grained	d
1 - 3.5	sand, brown, firmly packed, fine grained, oxidized streaks	d
3.5 - 4.5	clay, brown, firm, sandy	sm - m
4.5 - 9	till, grey, firm, some pebbles	m - vm
9 - 10	till, grey, firm, some pebbles	s

installation: watertable well, 10 m deep, slotted 5.5 - 10 m, 2" PVC pipe

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole #406		
0 - 1	sand, grey, fine to medium grained, loose	d
1 - 6	sand, brown, fine to medium grained, loose	sm - m
6 - 8	sand, light brown, fine to medium grained,	m - vm
8 - 9	sand, light brown, fine to medium grained	s
installation:	watertable well, 9 m deep, slotted 4.5 - 9 m, 2" PVC pipe	
Test Hole #407		
0 - 1.5	sand, grey, fine to medium grained, losse	d
1.5 - 4.5	sand, brown, fine to medium grained, loose	sm
4.5 - 5	sand, light brown, some silt and clay, plastic	m
5 - 8.5	clay, dark brown, silty plastic	m
8.5 - 10.5	sand, brown, fine, some silt, iron oxide streaks	s
installation:	watertable well, 10.5 m deep, slotted 6 - 10 m, 2" PVC pipe	
Test Hole #408		
0 - 1	sand, grey, fine grained, loose	d
1 - 3	sand, brown, fine grained, loose	sm - vm
3 - 6	sand, brown, fine grained, more clay	vm - s
installation:	watertable well, 6 m deep, slotted 3 - 6 m, 2" PVC pipe	

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole #409		
0 - 1	sand, grey, fine grained, loose	d
1 - 3	sand, brown, fine to medium grained	vm - s
3 - 5.5	sandy till, brown, firm, iron oxide streaks	s
5.5 - 7	sandy till, grey, firm	s
7 - 7.5	sand, brown, fine grained, quick	s

installation: piezometer, 7.5 m deep, .4 m screen, 2" PVC pipe

Test Hole #410

same as #409

installation: watertable well, 5 m deep, slotted 2 - 5 m below ground level

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

NEW SAREPTA LANDFILL

NW 34-49-22-W4

LOCATION AND SITE DESCRIPTION

- the site, about 2.5 ac (1 ha) in area, is located approximately 1 km northeast of New Sarepta (Figure 1);
- the land slopes gently to the southwest;
- a wetland area is present to the south of the site;
- it is an active site, operated by the County of Leduc for the Village of New Sarepta and surrounding area;
- primarily domestic waste is disposed of at the site.

FIELD PROGRAM

Test Drilling and Monitor Completion

- six testholes drilled (locations shown in Figure 2 and borehole logs attached);
- four water table wells and two piezometers installed at four sites (completion details - Table 1).

EM Survey

- EM 31 instrument in vertical and horizontal mode was used;
- seven transects were completed with 20 m between measurement points (Figure 3 & 4).

Monitoring

- water levels wre recorded on September 5, 1985 (Table 2);
- groundwater samples were collected for chemical analysis on September 17, 1985 (Table 3).

STUDY RESULTS

Geology

- in the vicinity of the landfill, domestic well lithologs indicate that clay till, 10 - 15 m thick, overlies bedrock comprised of shale interspersed with coal seams;

- drilling established that the site is underlain predominantely by silty clay till to a depth of at least 6 m. A sand lense of 1 m thickness was penetrated by P325;
- garbage has been deposited during the last 30 years in numerous cells throughout the site. The cells are approximately 3 m deep.

Hydrogeology

- shallow groundwater flow is toward the southwest;
- the average depth to the water table in the site is approximately 1.8 m;
- the swamp area at the south of the site is probably perched above the water table;
- hydraulic conductivity of the silty clay is estimated to be about 10^{-6} cm/s.

EM Survey

- conductivity values and contours are shown in Figure 3 & 4;
- background conductivity values are approximately 20 and 30 m S/cm for the 3 m and 6 m depth, respectively;
- the south central part of the site is characterized by high conductivity values with the highest values coinciding with a covered refuse cell in the west centre of the site;
- the high conductivity values extend beyond the western perimeter of the site in the direction of groundwater flow;
- a second area of high conductivity values is located outside the northwest corner of the site, down-gradient from an open, water filled refuse cell;
- the north-eastern part of the site shows conductivity values similar to background and appears not to have been affected by groundwater pollution.

Groundwater Chemistry

- background water is predominantely the sodium-bicarbonate type with a total dissolved solids concentration of 400 - 800 mg/L;
- well W329, located adjacent to a covered refuse cell, contains water high in iron, chloride and TDS;

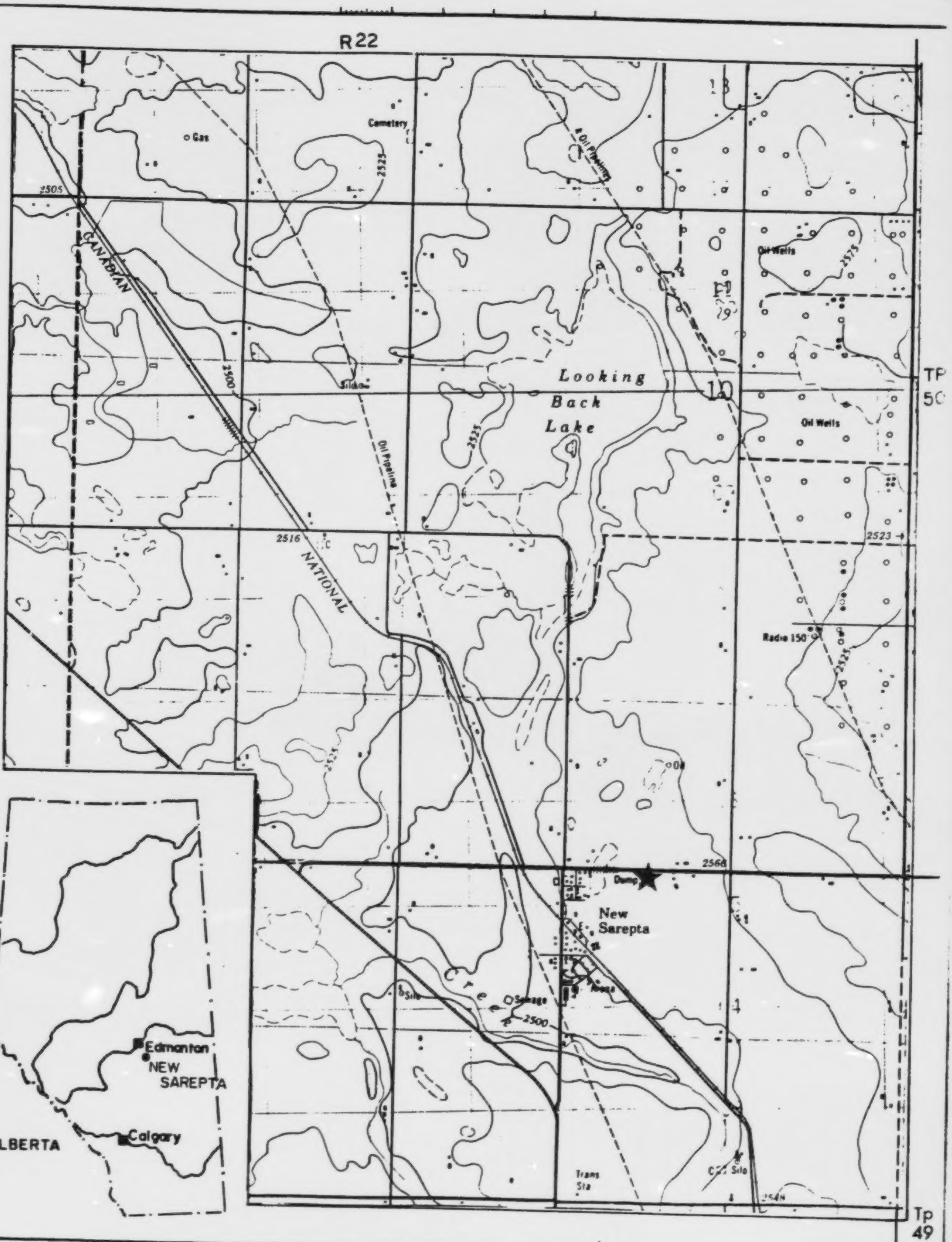
- of the other wells only groundwater from W327, located near a seasonally wet area, has constituents which exceed established values for drinking water (see Table 3).

CONCLUSIONS

- the site is underlain by low permeability till and has a shallow water table;
- shallow groundwater in the immediate vicinity of the dump site has been contaminated; however; the level of contamination is low and poses no health risk.

RECOMMENDATION

- it is recommended that the trenches not be excavated below the water table since waste in contact with water generates leachate (the trench in the northwest corner of the site);
- it is recommended that monitoring at the landfill site be discontinued and that the site be down graded to a lower priority.


R22
TP 50
Tp 49
Gas
Cemetery
2505
2525
2500
2516
2523
2566
Oil Pipeline
CANADIAN
NATIONAL
Silo
Oil Wells
Looking Back Lake
Radio 150
Dump
New Sarepta
Creek
Sewage
Trans Sta
Silo
ALBERTA
Edmonton
NEW SAREPTA
Calgary

Alberta ENVIRONMENT

NEW SAREPTA

LOCATION PLAN

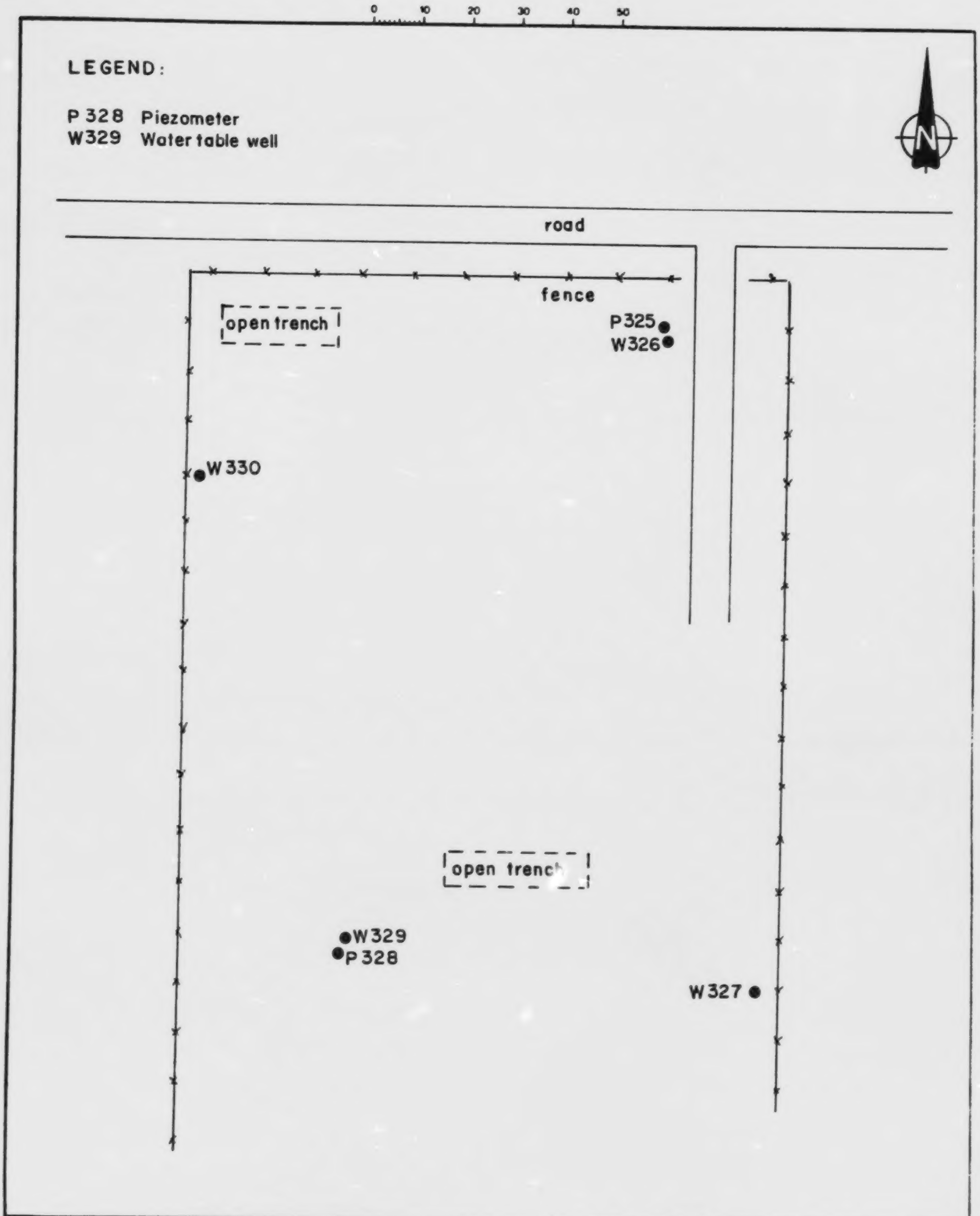
SUBMITTED		DESIGNED	
DATE	Feb. 14/86.	CHECKED	
APPROVED		DRAWN	
DATE	Feb. 14/86	CHECKED	

SCALE 1:50000

DATE

SHEET OF

FIGURE No. 1


0 10 20 30 40 50
LEGEND:
P 328 Piezometer
W329 Water table well
N
road
fence
open trench
P325
W326
W 330
open trench
W329
P 328
W 327

Alberta ENVIRONMENT EARTH SCIENCES DIVISION

NEW SAREPTA LANDFILL

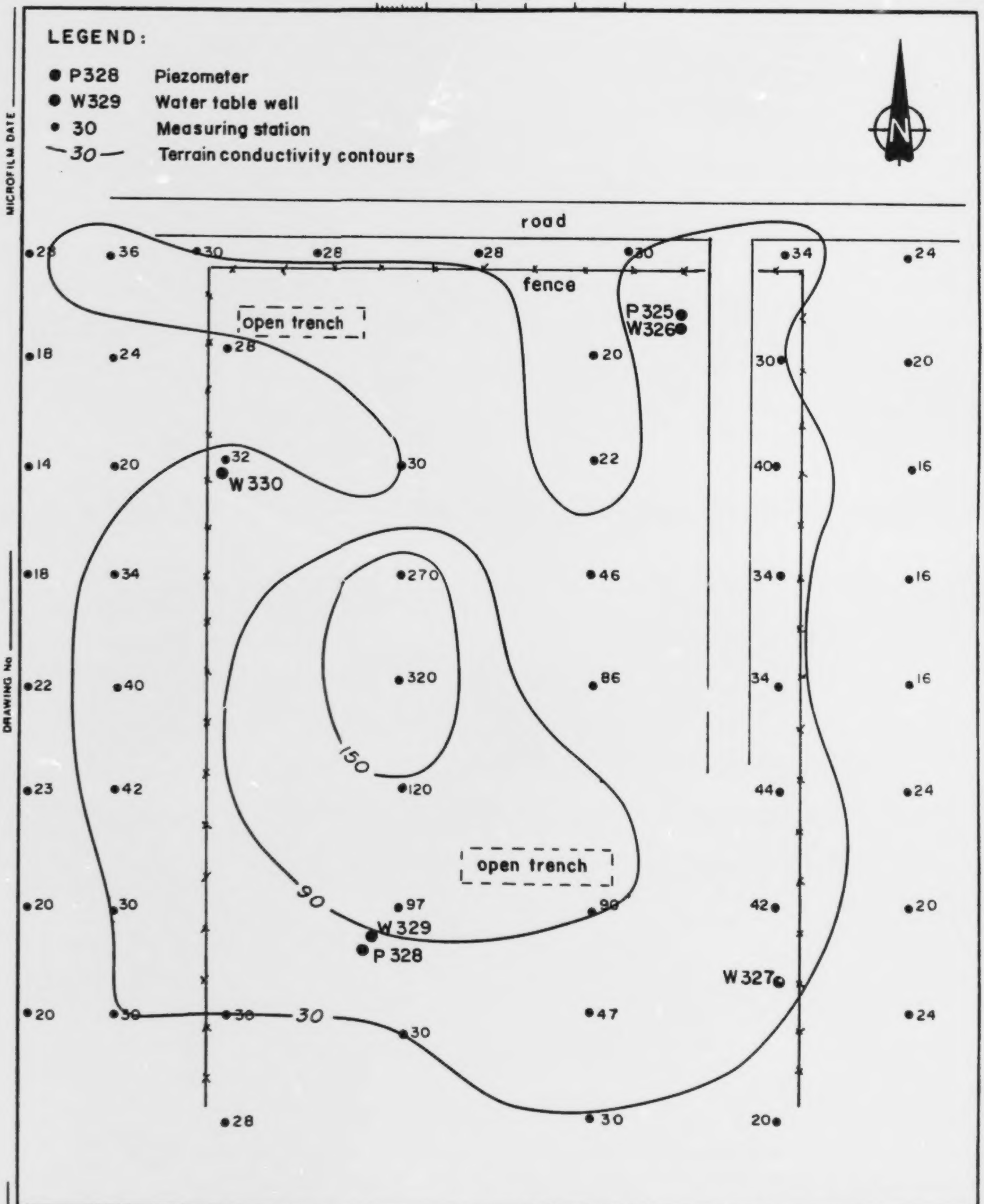
SITE PLAN

SUBMITTED W. J. [illegible]
DATE Feb. 14/86
APPROVED C. J. McCracken
DATE Feb. 14/86
DESIGNED MD
CHECKED
DRAWN MD
CHECKED
SCALE 1 = 800
DATE
SHEET OF
FIGURE No. 2

MICROFILM DATE

DRAWING No

FILE No


LEGEND:
● P328 Piezometer
● W329 Water table well
• 30 Measuring station
—30— Terrain conductivity contours
N
road
fence
open trench
open trench
P325
W326
W330
W329
P328
W327
28
36
30
28
28
30
34
24
18
24
28
20
30
20
14
20
32
30
22
40
16
18
34
270
46
34
16
22
40
320
86
34
16
150
23
42
120
44
24
90
20
30
97
90
42
20
20
30
30
30
30
47
24
28
30
20

Alberta
ENVIRONMENT

SUBMITTED W. J. Gum
DATE Feb. 14/86
APPROVED
DATE Feb. 14/86

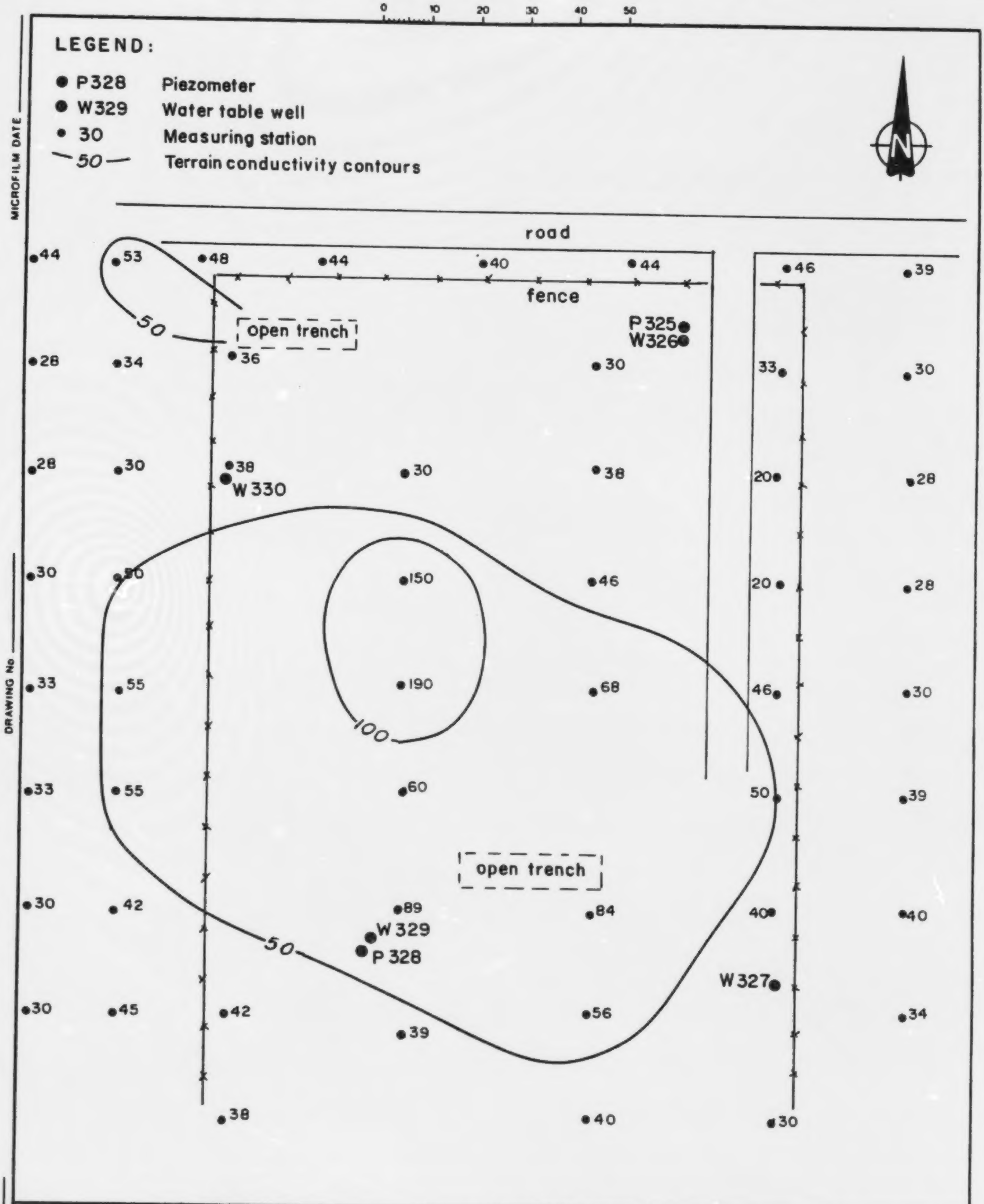
DESIGNED MD
CHECKED
DRAWN MD
CHECKED

NEW SAREPTA LANDFILL

TERRAIN CONDUCTIVITY (mS/cm)

approx. 3m below ground level

SCALE 1=800
DATE
SHEET OF
FIGURE No. 3


0
10
20
30
40
50
LEGEND:
● P328 Piezometer
● W329 Water table well
• 30 Measuring station
—50— Terrain conductivity contours
N
road
fence
open trench
open trench
50
50
100
44
53
48
44
40
44
46
39
P325
W326
28
34
36
30
33
30
28
30
38
W330
30
38
20
28
30
50
150
46
20
28
33
55
190
68
46
30
33
55
60
50
39
30
42
89
W329
P328
84
40
40
W327
30
45
42
39
56
34
38
40
30

MICROFILM DATE
DRAWING No.
FILE No.

Alberta
ENVIRONMENT

SUBMITTED W. J. Gruni
DATE Feb. 14/86
APPROVED
DATE Feb. 14/86

DESIGNED MD
CHECKED
DRAWN MD
CHECKED

NEW SAREPTA LANDFILL

TERRAIN CONDUCTIVITY (mS/cm)

approx. 6 m below ground level

SCALE 1=800
DATE
SHEET OF
FIGURE No. 4

TABLE 1: MONITORING WELL COMPLETION

Well Number	Date Installed	Well Depth (m)	Height of pipe above ground surface (m)	Screened interval (m)	Ground elevation (m)	Elevation of pipe (m)	Pipe diameter (m)
P325	18 7 85	7.5	1.00	6.85 - 7.5	99.72	100.72	50
W326	18 7 85	5	1.02	1.5 - 5.0	99.80	100.82	50
W327	18 7 85	6	0.82	1.5 - 6.0	98.80	99.62	50
P328	18 7 85	7.5	0.86	7.0 - 7.5	99.66	100.52	50
W329	18 7 85	4.5	1.06	1.5 - 4.5	100.22	100.28	50
W330	18 7 85	6	0.96	1.5 - 6	99.63	100.59	50

TABLE 2: WATER LEVEL DATA (85 09 05)

Well Number	Water Level Depth (b.g.l.) (m)	Elevation (m)
P325	3.06	96.66
W326	2.68	97.12
W327	1.43	97.32
P328	1.92	97.74
W329	2.10	97.12
W330	1.49	98.14

TABLE 3: WATER ANALYSIS RESULTS

	Well Numbers						
	325	326	327	328	329	330	C.D.W.S.
FIELD DATA							
Temp. (°C)							
EC (mS/cm)	1.10	.97	2.8	1.14	1.75	.85	
pH	7.83	7.50	7.52	7.38	7.22	7.33	
LAB DATA							
pH	8.47	8.29	8.02	8.09	7.93	8.34	
EC (mS/cm)	1.22	1.02	2.49	1.18	1.91	.88	
SAR	9.1	3.1	1.6	2.0	3.3	.4	
LAB ANALYSIS (all parameters in mg/L)							
Inorganic							
Ca	41	46	320	109	156	99	NE**
Mg	9.6	25.2	120.0	31.8	54.0	35.5	150
CaCO$_3$ (T. Hard.)	142.5	220.5	1300	405	615	395	500
Na	251.8	106.3	131.7	92	189.4	18.5	300
K	4.3	4.3	7.0	7.8	17.2	4.3	NE
HCO$_3$	653.3	372.1	494.7	479.5	558.1	268.4	NE
CaCO$_3$ (T.Alk)	535.5	305	405	393	475.5	220	500
SO$_4$	122.4	88.8	1070.4	201.6	280.8	146.4	500
Cl	15.07	35.45	75.33	6.20	199.58	33.68	250
NO$_3$-N&NO$_2$-N	.14	.07	.07	.15	1.40	<.07	10
NH$_4$-N	1.33	.07	.14	1.05	2.10	.14	.5
TDS	766	489	1968	676	1172	470	1000
Organic							
COD	90	17	40	39	74	28	
TOC	20.5	8.7	10.4	129.7	16.4	8.3	
TIC	136	113.5	90.1	11.3	118.9	47.2	
TC	156.5	122.2	100.5	141.0	135.3	55.5	
Metals							
Fe	.03	.03	.05	.07	4.55	.04	.3
Mn	.17	.25	.17	1.28	2.73	.39	.05
Cu	<.01	<.01	.01	.01	.01	<.01	1.0
Zn	.02	.01	.02	.01	.03	.01	5.0
Pb	.03	.02	.06	.04	.05	.02	.05

* Canadian Drinking Water Standards

** Not Established

SOILS BRANCH DRILL HOLE LOG

Land Location NW Sec. 34 Tp. 49 R. 22 W. 4

Date July 18, 1985 Supervisor M. deBrentani

Project New Sarepta

Test Hole 325 to 330 inclusive.

Test Hole 325

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - 2	till, silty clay, grey brown, firm, some pebbles and coal	m
2 - 3	sand, fine, brown, silty	s
3 - 4.5	till, silty clay, grey brown, firm, some oxidized layers	m
4.5 - 7.5	till, silty clay, dark brown, firm, more uniform texture	m

installation: piezometer, 7.5 m deep, .65 m screen, 2" PVC pipe

Test Hole #326

Same as #325

installation: water table well, 5 m deep, slotted 1.5 - 5 m below ground level (b.g.l.), 2" PVC pipe

Test Hole #327

0 - .5	top soil, peaty, dark brown, soft	m
.5 - 1.5	till, silty clay, grey brown, firm, some oxidized layers	m
1.5 - 5	till, silty clay, grey brown, firm, more uniform texture	m
5 - 6	till, silty clay, grey, plastic, more uniform texture	vm

installation: water table well, 6 m deep, slotted 1.5 - 6 m b.g.l., 2" PVC pipe

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole #328		
0 - 2	garbage and fill material	
2 - 3	till, silty clay, very dark brown, firm, some peat	m
3 - 7.5	till, silty clay, grey brown, plastic, very silty	s
installation:	piezometer, 7.5 m deep, .5 m screen (2" PVC)	
Test Hole #329		
same as #328		
installation:	water table well, 4.5 m deep, slotted 1.5 - 4.5 m b.g.l., 2" PVC pipe	
Test Hole #330		
0 - 1.5	till, silty clay, dark brown, firm, oxidized layers	m
1.5 - 6	till, silty clay, brown, plastic, more uniform texture	m
installation:	water table well, 6 m deep, slotted 1.5 - 6 m b.g.l., 2" PVC pipe	

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

PARADISE VALLEY LANDFILL

NW 7-47-2-W4

LOCATION AND SITE DESCRIPTION

- the site is located 1 km northeast of Paradise Valley (Figure 1) adjacent to Briker Lake, an alkali lake;
- the land slopes gently to the east;
- primarily domestic refuse is disposed of at the site;
- the area of the disposal site is approximately 3.5 ac (1.5 ha).

FIELD PROGRAM

Test Drilling and Monitor Completion

- four testholes drilled at three locations (locations shown in Figure 2 and lithologs attached);
- three water table wells and a piezometer installed (completion details on bore hole logs).

EM Survey

- terrain conductivity survey conducted using the EM-31 in vertical mode (depth of penetration approximately 3 m) and in horizontal mode (depth of penetration approximately 6 m);
- seven transects were completed with a distance of 6 m between measuring points (Figure 3 and 4).

Monitoring

- water levels recorded on September 11, 1985;

Well Number	Water level, m (below ground surface)
W468	3.46
W469	2.41
W470	3.18
P471	3.44

- groundwater samples collected for chemical analysis on September 11, 1985 (results in Table 1).

STUDY RESULTS

Geology

- surficial materials consist predominantely of brown, silty-sandy till with intercalated fine-grained sand lenses up to 1 m thick;
- bedrock was not penetrated.

Hydrogeology

- shallow groundwater flow is to east toward Briker Lake;
- the average depth to the water table in the landfill area is 3 m;
- water level data from nest W470/P471 indicates that the site is located in a groundwater recharge area;
- the hydraulic conductivity of shallow geologic materials is in the 10^{-4} to 10^{-6} cm/s range.

EM Survey

- highest terrain conductivity values at both the 3 and 6 m depth recorded in the refuse area;
- elevated conductivity values east of the open trench suggest that contaminants are moving off-site in the direction of groundwater flow.

Hydrochemistry

- groundwater from W468 and W470, located upgradient from the landfill, indicate background water is the calcium/magnesium-bicarbonate sulphate type;
- the analysis of the groundwater sample from P471 suggests that the sulphate and total dissolved solids concentrations increase with depth;
- elevated chloride, nitrate and total dissolved solids concentrations suggest that groundwater immediately down-gradient from the landfill has been contaminated;
- the anomolously high organic content in groundwater from W470 is suspect and probably attributable to analytical error.

CONCLUSIONS

- groundwater down-gradient from the landfill has been contaminated by leachate;
- leachate-contaminated groundwater is characterized by elevated chloride, nitrate, total dissolved solids and manganese concentrations. However, only the latter three parameters slightly exceed upper limits for Canadian Drinking Water;
- it is not expected leachate-contaminated groundwater will pollute the lake due to the low hydraulic conductivity of shallow geologic materials (which will limit groundwater movement) and the poor quality of water in Bricker Lake.

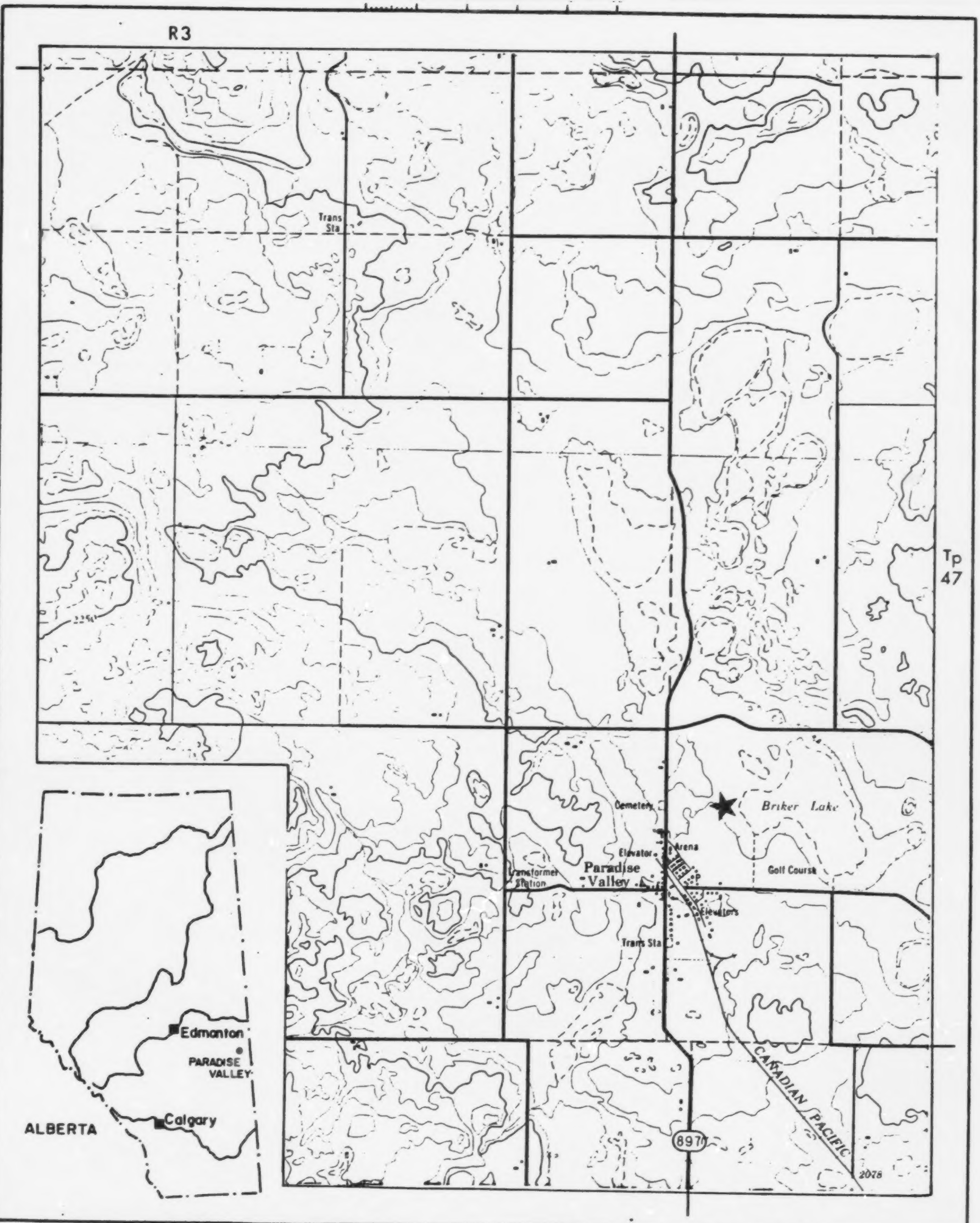
RECOMMENDATIONS

- it is recommended that monitoring be discontinued and that the site be down-graded to a low priority.

MICROFILM DATE

DRAWING No

FILE No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Tp 47
Trans Sta
2256
Cemetery
Briker Lake
Arena
Elevator
Paradise Valley
Transformer Station
Golf Course
Elevators
Trans Sta
CANADIAN PACIFIC
897
2076
Edmonton
PARADISE VALLEY
Calgary
ALBERTA

Alberta
ENVIRONMENT

SUBMITTED W. J. Aron
DATE Feb. 14/86

APPROVED L. McCracken
DATE Feb. 14/86

DESIGNED
CHECKED
DRAWN
CHECKED

PARADISE VALLEY LANDFILL

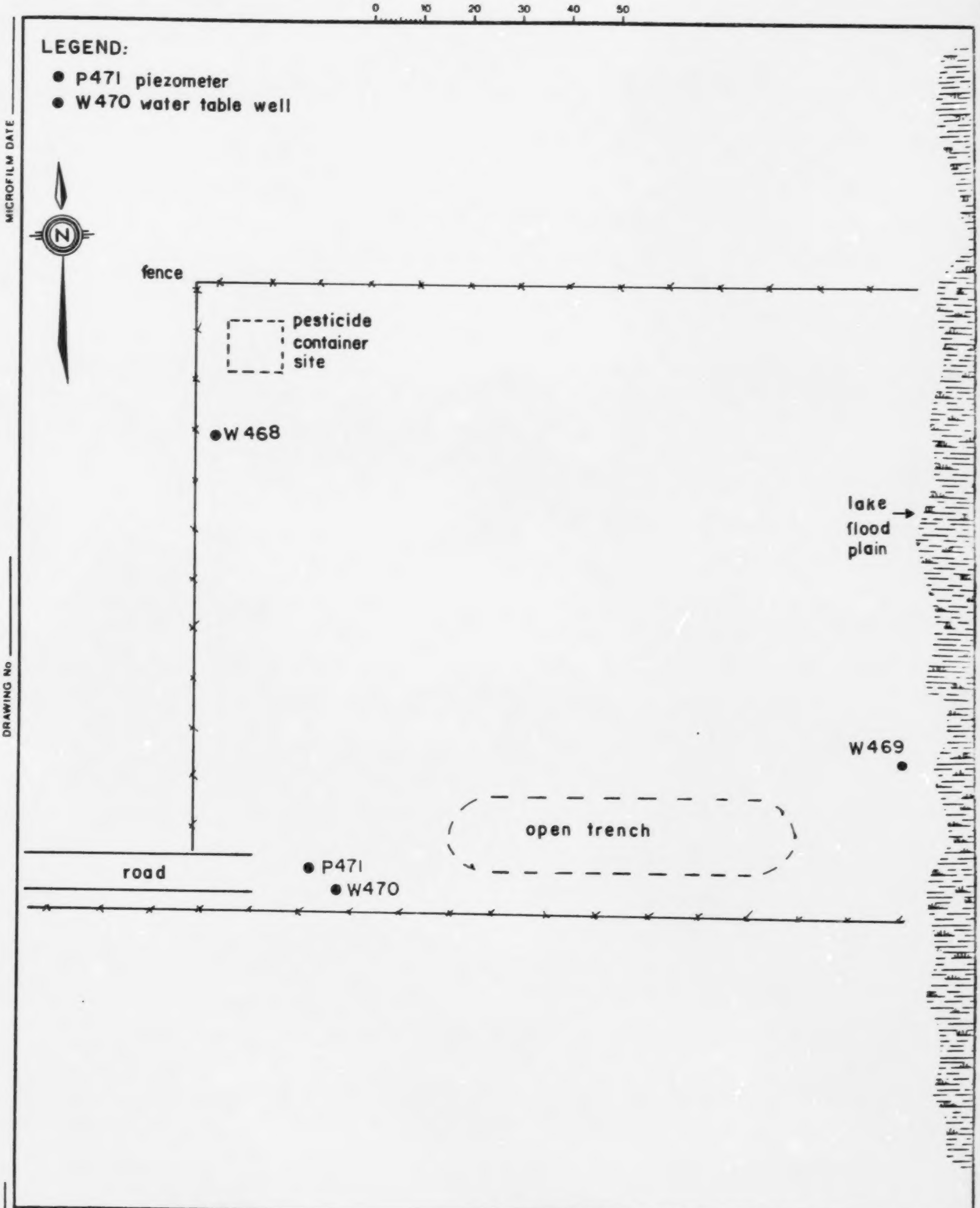
LOCATION PLAN

SCALE 1=50000
DATE
SHEET OF
FIGURE No. 1

MICROFILM DATE

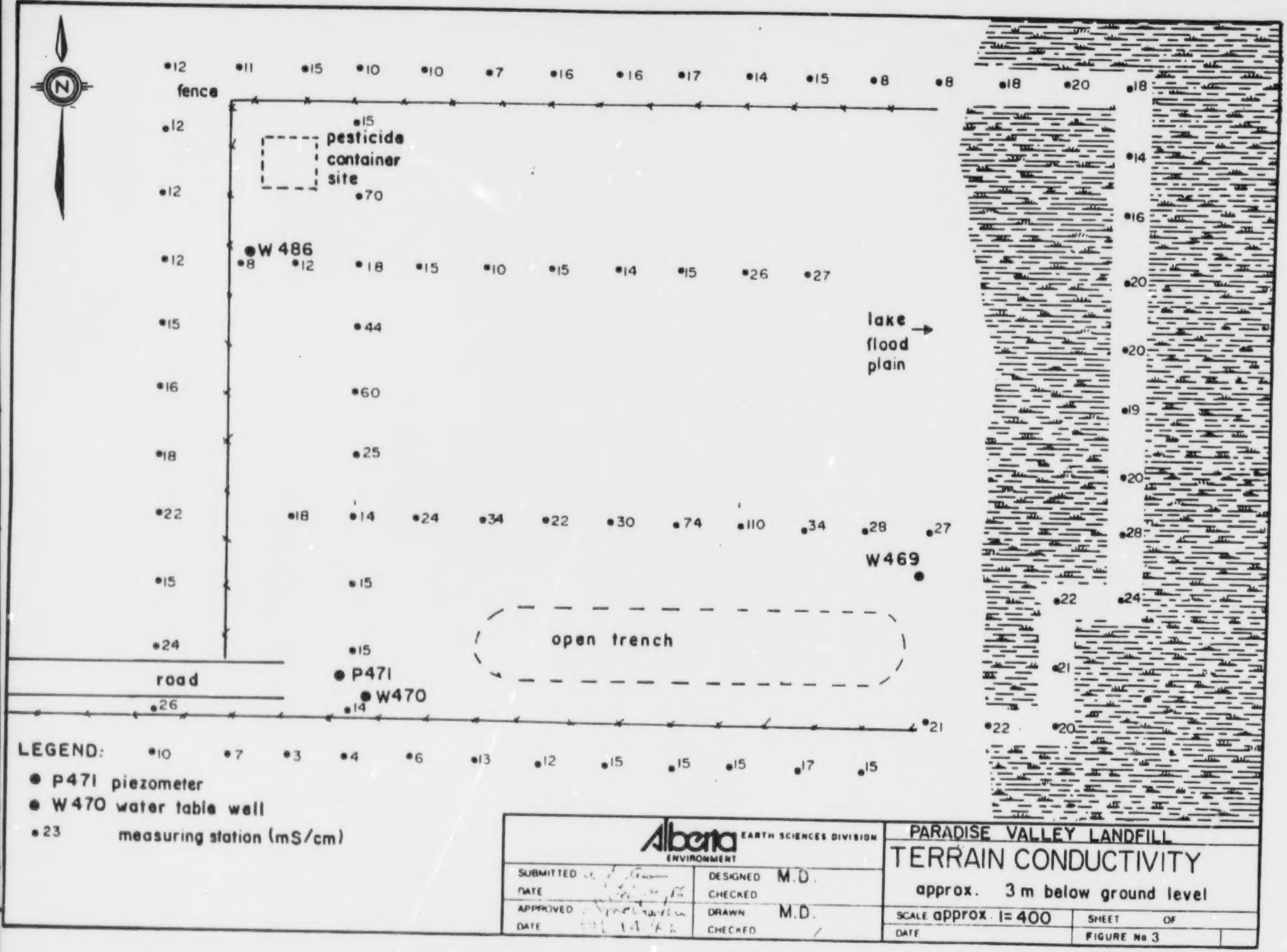
DRAWING No

FILE No


0
10
20
30
40
50
LEGEND:
● P471 piezometer
● W470 water table well
N
fence
pesticide container site
W 468
lake flood plain
W469
open trench
road
P471
W470

Alberta
ENVIRONMENT

SUBMITTED W. J. Teron DATE Feb. 14/86	DESIGNED W.C. CHECKED	PARADISE VALLEY LANDFILL SITE PLAN	
APPROVED DATE Feb. 14/86	DRAWN M.D. CHECKED	SCALE not to scale DATE	SHEET OF FIGURE No. 2


fence
pesticide container site
W 486
lake flood plain
W469
open trench
road
P471
W470
•12 •11 •15 •10 •10 •7 •16 •16 •17 •14 •15 •8 •8 •18 •20 •18
•12 •15 •14
•12 •70 •16
•12 •8 •12 •18 •15 •10 •15 •14 •15 •26 •27 •20
•15 •44 •20
•16 •60 •19
•18 •25 •20
•22 •18 •14 •24 •34 •22 •30 •74 •110 •34 •28 •27 •28
•15 •15 •22 •24
•24 •15 •21
•26 •14 •21 •22 •20
•10 •7 •3 •4 •6 •13 •12 •15 •15 •15 •17 •15
LEGEND:
● P471 piezometer
● W470 water table well
•23 measuring station (mS/cm)

Alberta ENVIRONMENT EARTH SCIENCES DIVISION

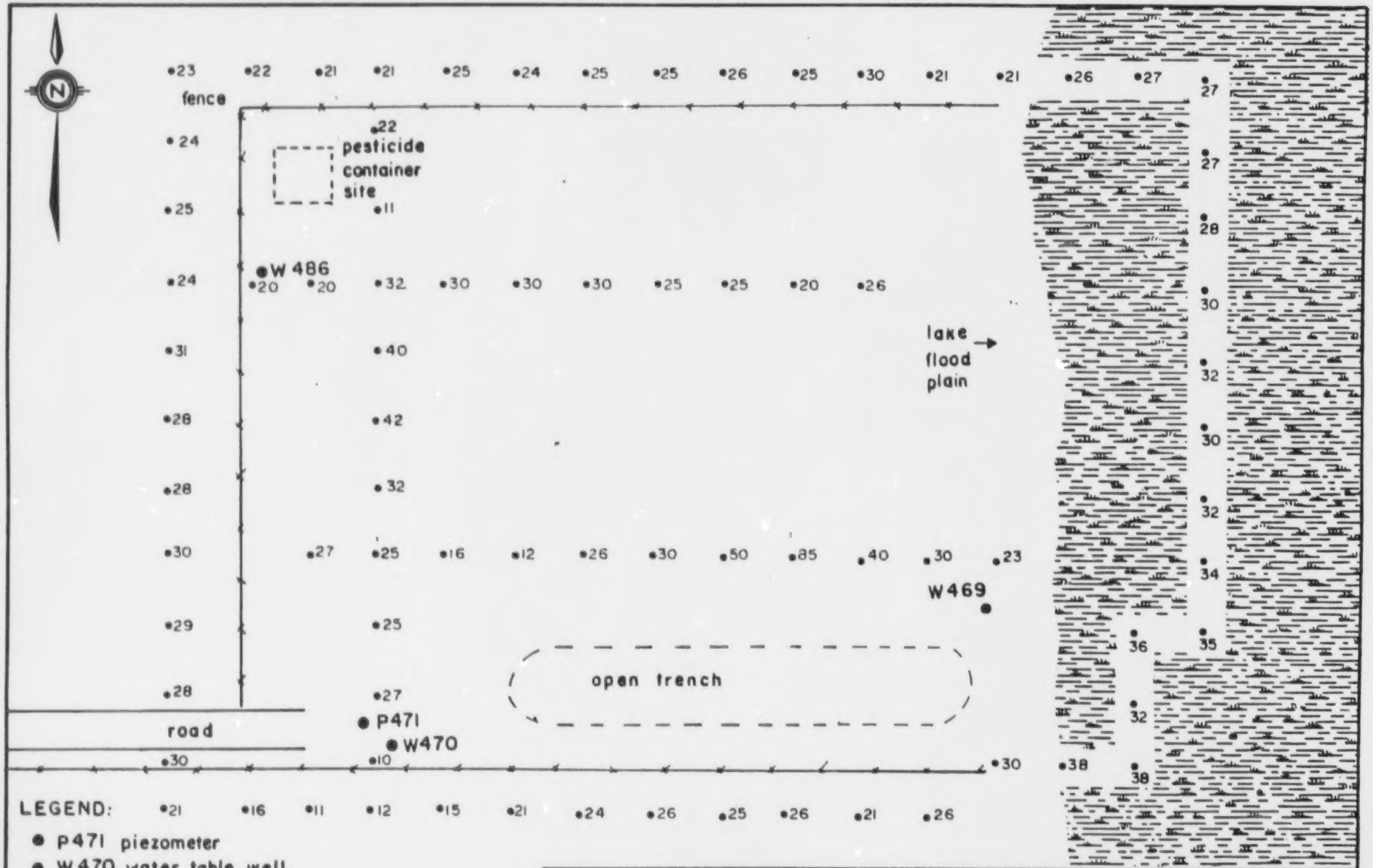
SUBMITTED	DESIGNED M.D.
DATE	CHECKED
APPROVED	DRAWN M.D.
DATE	CHECKED

PARADISE VALLEY LANDFILL

TERRAIN CONDUCTIVITY

approx. 3 m below ground level

SCALE approx. 1= 400
SHEET OF
DATE
FIGURE No 3


N
•23 •22 •21 •21 •25 •24 •25 •25 •26 •25 •30 •21 •21 •26 •27 •27
fence
•24 •22 pesticide container site •27
•25 •11 •28
•24 W 486 •20 •20 •32 •30 •30 •30 •25 •25 •20 •26 •30
•31 •40 lake → flood plain •32
•28 •42 •30
•28 •32 •32
•30 •27 •25 •16 •12 •26 •30 •50 •85 •40 •30 •23 •34
W469
•29 •25 •36 •35
open trench
•28 •27 •32
road
P471
W470
•30 •10 •30 •38 •38
•21 •16 •11 •12 •15 •21 •24 •26 •25 •26 •21 •26

LEGEND:
- ● P471 piezometer
- ● W470 water table well
- • 28 measuring station (mS/cm)

Alberta ENVIRONMENT EARTH SCIENCES DIVISION

SUBMITTED	DESIGNED M.D.
DATE	CHECKED
APPROVED	DRAWN M.D.
DATE	CHECKED

PARADISE VALLEY LANDFILL

TERRAIN CONDUCTIVITY

approx. 6 m below ground level

SCALE approx 1=400 SHEET OF

DATE FIGURE No 4

TABLE 1: CHEMICAL ANALYSIS RESULTS

	Well Numbers				
	W468	W469	W470	W471	C.D.W.S
FIELD DATA					
Temp. (°C)	6.8				
EC (mS/cm)	0.75	2.0	0.85	1.35	
LAB DATA					
pH	7.7	7.7	7.9	8.15	
EC (mS/cm)	0.7	2.4	0.78	1.46	
SAR	0.8	1.01	0.81	1.19	
LAB ANALYSIS (all parameters in mg/L)					
Inorganic					
Ca	78	223	90	153	
Mg	30	84	39.6	83	150
$CaCO_3$ (T.Hard)	320	910	845	730	500
Na	35	236	37	74	300
K	43	5.5	4.3	5	
HCO	262	638	326	405	
$CaCO_3$(T.Alk)	261	523	268	332	500
SO_4	125	571	194	499	500
Cl	7	154	13.6	21	250
NO_3-N+NO_2-N	0.07	19.6	0.05	4.3	10
NH_4-N	0.07	0.2	0.28	0.14	0.05
TDS	436	1674	530	1053	1000
Organic					
COD	6	37	927	31	
TOC	3.8	9.9	233	10.2	
TIC	65	90.1	66	79.4	
TC	68.8	100	299	89.6	
Metals					
Fe	0.01	0.02	0.05	0.03	0.3
Mn	0.02	0.3	0.52	0.88	0.05
Cu	<0.01	0.01	<0.01	0.01	1.0
Zn	0.01	0.02	<0.01	0.01	5.0
Pb	0.02	0.04	0.02	0.05	0.05

* Canadian Drinking Water Standards

SOILS BRANCH DRILL HOLE LOG

Land Location NW Sec. 7 Tp. 47 R. 2 W. 4

Date September 4, 1985 Supervisor W. Ceroici

Project Paradise Valley Landfill

Test Hole 468 to 471 inclusive.

Test Hole 468

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - 0.5	topsoil, black sandy	d
0.5 - 1.5	sand, brown, fine	d
1.5 - 3.5	till, brown, some sand	sm - m
3.5 - 4.5	sand, brown, fine	s
4.5 - 6	till, grey-brown, sandy	s

Installation: watertable well, 5 m deep, slotted 2.5 - 5 m below ground, 2" PVC pipe

Test Hole #469

0 - 1.5	fill	d
1.5 - 4.5	till, brown, sandy	m - s
4.5 - 6	till, brown, sandy to silty	s

Installation: watertable well, 6 m deep, slotted 3 - 6 m b.g.l., 2" PVC pipe

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole #470		
0 - 0.5	topsoil, black	d
0.5 - 1.5	sand, brown, fine	d
1.5 - 3	till, brown, sandy	m
3 - 4.5	till, brown, less sandy	s
4.5 - 7.5	till, grey brown, silty	s

Installation: piezometer 7.5 m deep screen 7 - 7.5 m b.g.l., 2" PVC pipe

Test Hole #471

Same as #470

Installation: watertable well, 6 m deep, slotted 3 - 6 m b.g.l., 2" PVC pipe

RED DEER (MONTFORT SCHOOL) LANDFILL

NE 20-38-27-W4

LOCATION AND SITE DESCRIPTION

- the site, approximately 3.7 ac (1.5 ha) in area, is located in Red Deer behind Montfort school (Figure 1);
- the site, which has been reclaimed, is bordered by residential developments to the north, west and east;
- primarily domestic waste was reportedly disposed of at the site.

FIELD PROGRAM

Test Drilling and Monitor Completion

- seven testholes were drilled at five sites (locations shown in Figure 2 and lithologic logs attached);
- five water table wells and two piezometers were installed (completion details contained in Table 1).

Monitoring

- water levels recorded on July 16, 1985 (Table 2);
- groundwater samples collected for chemical analysis on July 30, 1985 (Table 3);
- groundwater samples collected on September 30, 1985 from wells P319 and W324 for GC/MS analysis (analysis results attached).

STUDY RESULTS

Geology

- predominant surficial material is silty clay till;
- till contains silty, fine grained sand lenses up to 1 m thick;
- bedrock was not penetrated.

Hydrogeology

- based on surface topography, the probable direction of shallow groundwater flow is toward the south;

- groundwater movement is sluggish due to the low hydraulic conductivity of surficial materials which is estimated to be $< 10^{-5}$ cm/s;
- water level data from nests P319/W320 and P322/W323, indicate the site is located in a groundwater recharge area;
- the average depth to the water table in the landfill area is 4 m.

Groundwater Chemistry

- groundwater from W321, representative of background conditions, is the calcium/magnesium-bicarbonate type with a total dissolved solids concentration <1000 mg/L;
- only total hardness, total alkalinity and manganese concentrations in background water exceed the upper limits for Canadian Drinking Water;
- groundwater from W318 and W324, completed in the refuse, is highly mineralized. The high total hardness, chloride, ammonium, C.O.D., iron and manganese concentrations indicate contamination by leachate. Contamination has resulted from the prolonged contact of groundwater with refuse encapsulated in low permeability surficial material (the disposal area was originally a slough);
- groundwater from W320, located down-gradient from the landfill, is characterized by high total dissolved solids, chloride, iron and manganese concentrations, suggesting leachate contamination;
- groundwater from P319, located immediately adjacent to W320 but 1.5 m deeper, is significantly less mineralized, suggesting that contaminants are effectively attenuated with depth;
- GC/MS analysis was conducted on groundwater from P319 and W324 to identify extractable priority pollutants. Results indicate the samples have very low concentrations of priority pollutants.

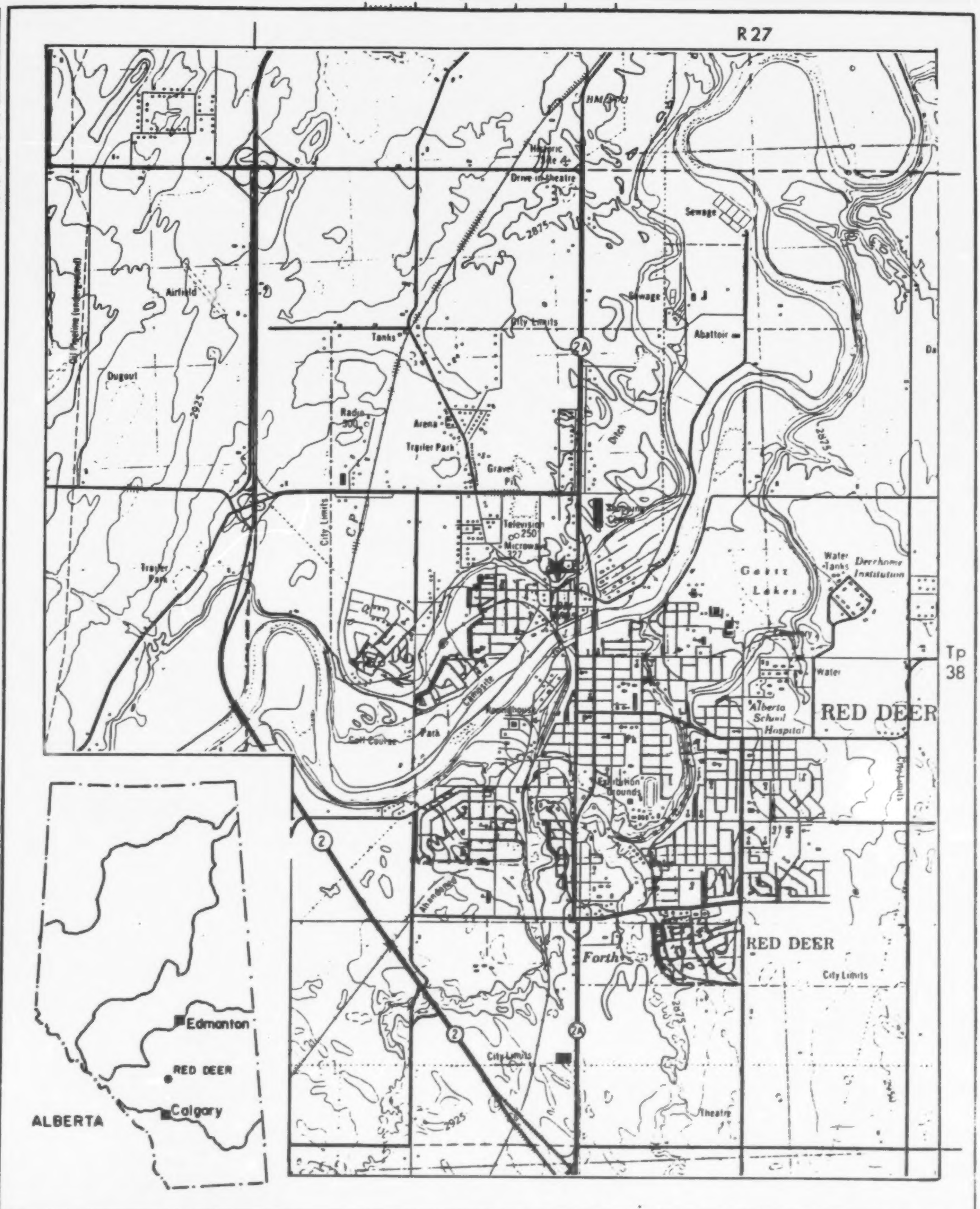
CONCLUSIONS

- the prolonged contact of groundwater with waste materials (due to sluggish shallow groundwater movement in the low permeability surficial materials) has resulted in highly mineralized water in the refuse;

- leachate-contaminated groundwater has migrated off-site through fine-grained sand lenses;
- since the sand layers are limited in areal extent and the till has a low hydraulic conductivity it is expected contaminant migration will be minimal.

RECOMMENDATIONS

- it is recommended that monitoring activities at the site cease and the site be downgraded to low priority.


R27
Tp 38
RED DEER
Historic Site
Drive-in theatre
Sewage
Airfield
Oil Pipeline (underground)
Dugout
2925
2875
Tanks
City Limits
2A
Abattoir
Radio 300
Arena
Trailer Park
Gravel Pit
Ditch
Television 250
Microwave 327
Shopping Centre
Trailer Park
City Limits
C.P.
Water Tanks
Deerhome Institution
Gaetz Lakes
Water
Alberta School Hospital
Campsite
Roundhouse
Golf Course
Park
Exhibition Grounds
2
Abandoned
Forth
RED DEER
City Limits
Theatre
Edmonton
RED DEER
Calgary
ALBERTA

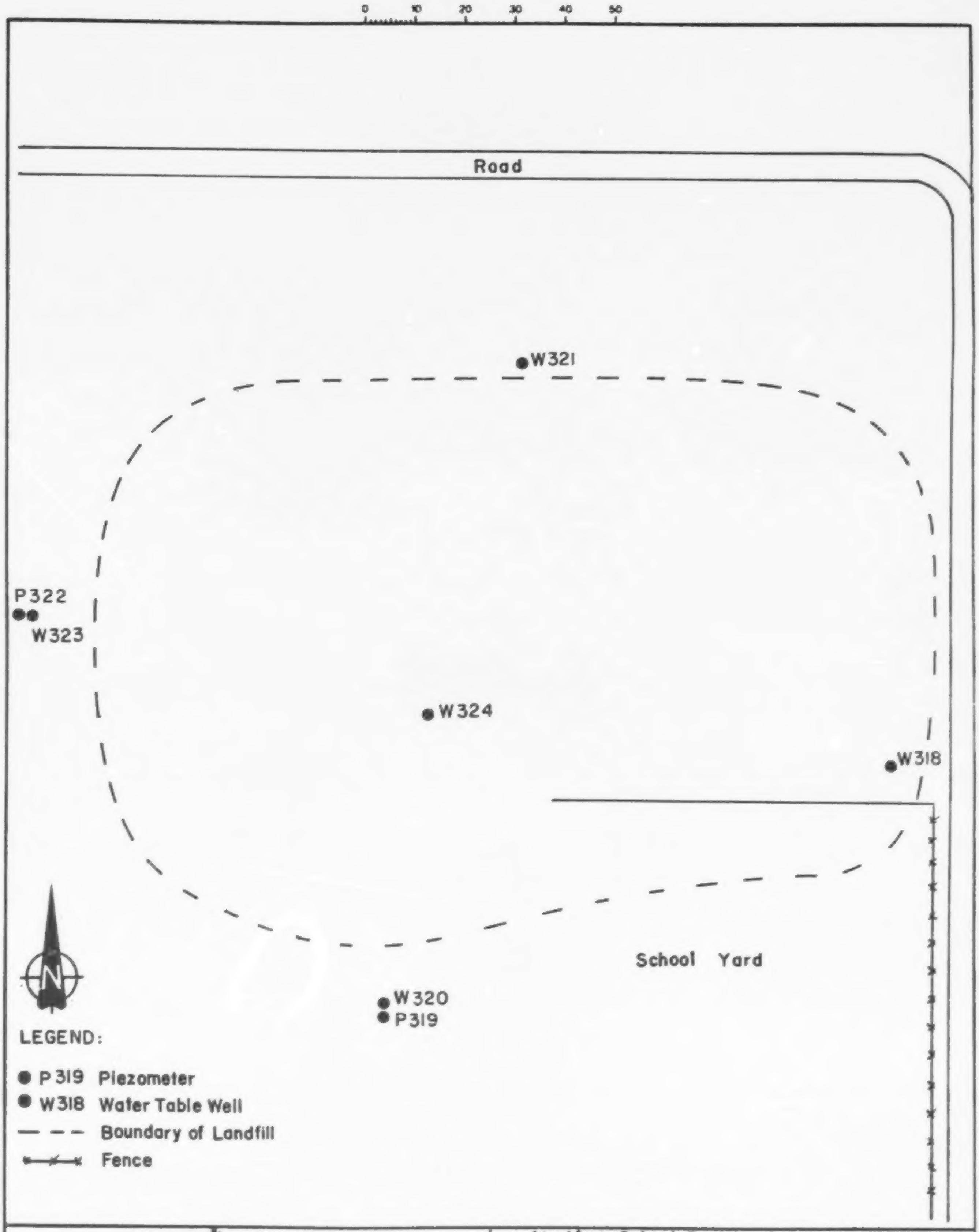
Alberta
ENVIRONMENT

SUBMITTED	DESIGNED
DATE Feb. 14. 86	CHECKED
APPROVED	DRAWN
DATE 1 Feb 14/86	CHECKED

RED DEER RECLAIMED LANDFILL (MONTFORD SCHOOL

LOCATION PLAN

SCALE 1:50000	SHEET OF
DATE	FIGURE No. 1


0
10
20
30
40
50
Road
W321
P322
W323
W324
W318
School Yard
W320
P319
N
LEGEND:
● P319 Piezometer
● W318 Water Table Well
— — — Boundary of Landfill
—x—x— Fence

Alberta ENVIRONMENT EARTH SCIENCES DIVISION		Montfort School Reclaimed School
SUBMITTED DATE Feb 14/86	DESIGNED MD CHECKED	SITE PLAN
APPROVED DATE Feb. 14/86	DRAWN MD CHECKED	SCALE 1 : 1000 DATE
		SHEET OF FIGURE No. 2

TABLE 1: MONITORING WELL COMPLETION INFORMATION

Well Number	Date Installed	Well Depth (m)	Height of pipe above ground surface (m)	Screened interval (m)	Ground elevation (m)	Elevation of pipe (m)
W318	11 7 85	4.5	.84	3.0 - 4.5	99.85	100.69
P319	11 7 85	6.0	.81	5.5 - 6.0	100.40	101.21
W320	11 7 85	4.5	.76	1.5 - 4.5	100.40	101.16
W321	11 7 85	6.0	.92	3.0 - 6.0	100.25	101.17
P322	11 7 85	7.5	.89	7.0 - 7.5	100.61	101.35
W323	11 7 85	5.0	.96	2.0 - 5.0	100.61	101.35
W324	11 7 85	4.5	.92	2.5 - 4.5	100.00	100.92

TABLE 2: WATER LEVEL DATA (85/07/16)

Well Number	Water Level (m) (below top of casing)	Elevation (m)
W318	3.53	97.16
P319	4.65	96.56
W320	4.61	96.55
W321	4.48	96.69
P322	7.80	93.55
W323	dry @ 6.14	95.21
W324	3.58	97.34

TABLE 3: WATER ANALYSIS RESULTS

	Well Numbers						
	318	319	320	321	324	322	C.D.W.S.*
FIELD DATA							
Temp. (°C)	10	6	7	8	9	8	
EC (mS/cm)	6.8	1.45	5.0	6.3	6.8	7.6	
pH	6	7.8	7.4	7.2	6.2	6.6	
LAB DATA							
pH	6.5	7.7	7.2	7.4	6.9	8.2	
EC (mS/cm)	5.2	1.4	3.8	1.4	5.1	0.6	
SAR	2.6	4.5	0.4	0.2	2.6	0.1	
LAB ANALYSIS (all parameters in mg/L)							
Inorganic							
Ca	410	78	346	143	356	346	
Mg	174	35	272	99	211	59	150
$CaCO_3$ (T. Hard.)	1750	343	2040	770	1770	295	500
Na	250	194	42	11.6	252	4.6	300
K	48	3.9	3.1	3.5	85	5.9	
HCO_3	1966	785	1293	924	2550	370	
$CaCO_3$ (T. Alk)	1611	647	1060	757	2091	303	500
SO_4	132	19.2	2.4	24	24	12	500
Cl	514	81	532	32.8	535	5.3	250
NO_3-N+NO_2-N	<0.14	<0.07	0.07	0.14	<0.21	0.77	10
HN_4-N	146	0.14	0.28	0.14	127	0.5	.5
TDS	2680	799	1840	740	2880	308	1000
Organic							
COD	3780	350	2150	27	744	96	
Metals							
Fe	3.75	1.59	22.1	0.09	125	0.02	0.3
Mn	2.43	1.2	3.03	1.22	1.39	0.18	0.05
Cu	0.02	0.01	0.01	0.01	0.01	0.01	1.0
Zn	0.06	0.01	0.02	0.02	0.03	0.01	5.0
Pb	0.08	0.04	0.07	0.03	0.07	0.02	0.05

* Canadian Drinking Water Standards

. EXTRACTABLE PRIORITY POLLUTANTS **P319** SAMPLE NO. T540-781

(GC/MS FILE NO. >C0716)

COMPOUND	AMOUNT µg/L
ACID GROUPS	
Benzoic Acid	
4-Chloro-m-cresol	
2-Chlorophenol	
2,4-Dichlorophenol	
2,4-Dimethylphenol	
4,6-Dinitro-o-cresol	
2,4-Dinitrophenol	
Hexadecanoic acid	
2-Nitrophenol	
4-Nitrophenol	
Pentachlorophenol	
Phenol	
2,4,5-Trichlorophenol	
2,4,6-Trichlorophenol	
BASE NEUTRAL GROUP	
Polynuclear Aromatics	
Acenaphthene	
Acenaphthylene	
Anthracene	
Benz(a)anthracene	
Benzo(k)fluoranthene	
Benzo(ghi)perylene	
Benzo(a)pyrene	
Chrysene	
Dibenz(ah)anthracene	
Fluoranthene	
Fluorene	
Indeno(1,2,3-cd)pyrene	
Naphthalene	trace
Perylene	
Phenanthrene	
Pyrene	

COMPOUND	AMOUNT µg/L
Chloroorganics	
Chlorobenzene	
2-Chloronaphthalene	
1,2-Dichlorobenzene	
1,3-Dichlorobenzene	
1,4-Dichlorobenzene	
Hexachlorobenzene	
Hexachlorobutadiene	
Hexachlorocyclopentadiene	
Hexachloroethane	
1,2,4-Trichlorobenzene	
Nitroaromatics	
Benzidine	
3,3'-Dichlorobenzidine	
2,4-Dinitrotoluene	
2,6-Dinitrotoluene	
1,2-Diphenylhydrazine	
Nitrobenzene	
N-Nitrosodimethylamine	
N-Nitrosodiphenylamine	
N-Nitrosodi-n-propylamine	
Halo Ethers	
4-Bromophenyl phenyl ether	
Bis(2-chloroethoxy)methane	
Bis(2-chloroethyl)ether	
Bis(2-chloroisopropyl)ether	
2-Chloroethyl vinyl ether	
4-Chlorophenyl phenyl ether	
Phthalate Esters	
Butylbenzylphthalate	
Di-n-butylphthalate	trace
Diethylphthalate	trace
Dimethylphthalate	trace
Di-n-octylphthalate	
Bis(2-ethylhexyl)phthalate	38

Blank spaces indicate less than detection limit.
Detection limit for ACID and BASE NEUTRAL GROUPS <1.0 µg/L
TRACE indicates the compound is observed at less than the detection limit.

OTHER:

50-100 µg/L conc. range
propyl methylester, mol. wt$\geq$126
heptanoic acid
fenchone
octanoic acid
benzenepropanoic acid

1 - 10 µg/L conc. range
methyl cyclopentanone
trimethyl benzenes, C_9H_{12} mol.wt=120
propanoic acid
isobenzofuranone, $C_8H_6O_2$ mol.wt=134

10- 50 µg/L conc. range
butanoic acid
pentanoic acid
hexanoic acid
C_9H_{10} alkyl benzene, mol. wt=118
benzoic acid
nonanoic acid
S_6 elemental sulphur
S_7 elemental sulphur
S_8 elemental sulphur

EXTRACTABLE PRIORITY POLLUTANTS **W 324** SAMPLE NO. T540-782

(GC/MS FILE NO. >C0717)

COMPOUND	AMOUNT µg/L
ACID GROUPS	
Benzoic Acid	
4-Chloro-m-cresol	
2-Chlorophenol	
2,4-Dichlorophenol	
2,4-Dimethylphenol	
4,6-Dinitro-o-cresol	
2,4-Dinitrophenol	
Hexadecanoic acid	
2-Nitrophenol	
4-Nitrophenol	
Pentachlorophenol	
Phenol	trace
2,4,5-Trichlorophenol	
2,4,6-Trichlorophenol	
BASE NEUTRAL GROUP	
Polynuclear Aromatics	
Acenaphthene	
Acenaphthylene	trace
Anthracene	
Benz(a)anthracene	
Benzo(k)fluoranthene	
Benzo(ghi)perylene	
Benzo(a)pyrene	
Chrysene	
Dibenz(ah)anthracene	
Fluoranthene	
Fluorene	
Indeno(1,2,3-cd)pyrene	
Naphthalene	trace
Perylene	
Phenanthrene	
Pyrene	

COMPOUND	AMOUNT µg/L
Chloroorganics	
Chlorobenzene	
2-Chloronaphthalene	
1,2-Dichlorobenzene	
1,3-Dichlorobenzene	trace
1,4-Dichlorobenzene	
Hexachlorobenzene	
Hexachlorobutadiene	
Hexachlorocyclopentadiene	
Hexachloroethane	
1,2,4-Trichlorobenzene	
Nitroaromatics	
Benzidine	
3,3'-Dichlorobenzidine	
2,4-Dinitrotoluene	
2,6-Dinitrotoluene	
1,2-Diphenylhydrazine	trace
Nitrobenzene	
N-Nitrosodimethylamine	
N-Nitrosodiphenylamine	
N-Nitrosodi-n-propylamine	trace
Halo Ethers	
4-Bromophenyl phenyl ether	
Bis(2-chloroethoxy)methane	
Bis(2-chloroethyl)ether	
Bis(2-chloroisopropyl)ether	
2-Chloroethyl vinyl ether	
4-Chlorophenyl phenyl ether	
Phthalate Esters	
Butylbenzylphthalate	
Di-n-butylphthalate	trace
Diethylphthalate	18
Dimethylphthalate	
Di-n-octylphthalate	
Bis(2-ethylhexyl)phthalate	16
Dicyclohexyl phthalate	7.5

Blank spaces indicate less than detection limit.
Detection limit for ACID and BASE NEUTRAL GROUPS <1.0 µg/L
TRACE indicates the compound is observed at less than the detection limit.

OTHER:

50-100 µg/L conc. range
- methyl phenol
- benzyl alcohol
- camphor
- menthanol
- aliphatic acids, mol. wt 88-368

10 - 50 µg/L conc. range
- methyl pentenone
- methyl cyclopentanone
- cycloheptane
- pentanoic acid
- fenchone

1 - 10 µg/L conc. range
- cyclohexanol
- trimethyl benzenes C_9H_{12} mol. wt=120
- alkyl cyclohexanes, $C_{10}H_{18}$ mol. wt=138
- $C_{10}H_{14}$ alkyl benzenes, mol. wt=134

SOILS BRANCH DRILL HOLE LOG

Land Location NE Sec. 20 Tp. 38 R. 27 W. 4

Date July 11, 1985 Supervisor M. deBrentani

Project Montfort School Reclaimed Landfill

Test Hole 318 to 324 inclusive.

Test Hole 318

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - .5	topsoil, dark brown, loose	d
.5 - 3.5	garbage	m - s
3.5 - 4.5	till, dark grey, soft, silty clay	s

installation: watertable well, 4.5 m deep, slotted 3 - 4.5 m below ground level, 2" PVC pipe

Test Hole #319

0 - 1.5	topsoil, light brown, loose	d
1.5 - 2.5	sand, brown, fine grained, silty	d
2.5 - 3	sand, brown, fine grained, silty	m
3 - 4.5	till, dark brown, firm, silty clay with yellow & grey sand streaks	m
4.5 - 6	clay, grey brown, firm, silty	s

installation: piezometer, 6 m deep, .5 m screen, 2" PVC pipe

Test Hole #320

same as #319

installation: watertable well, 4.5 m deep, slotted 1.5 - 4.5 m b.g.l., 2" PVC pipe

*Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole #321		
0 - .5	topsoil, brown, loose	d
.5 - 2	till, dark brown, silty clay	d
2 - 6	clay, grey, silty clay, iron oxide streaks	s
installation:	watertable well, 6 m deep, slotted 3 - 6 m b.g.l.	
Test Hole #322		
0 - 1	topsoil, dark brown, granular	d
1 - 3	till, dark brown, firm, silty clay	m
3 - 4.5	till, yellow brown, plastic, oxidized layers	m
4.5 - 7.5	till, greenish brown, plastic	m - s
installation:	piezometer, 7.5 m deep, .5 m screen, 2" PVC pipe	
Test Hole #323		
same as #322		
installation:	watertable well, 5 m deep, slotted 2 - 3 m b.g.l.	
Test hole #324		
0 - 1	fill	d - m
1 - 4.5	garbage (saturated at 2.7 m)	m - s
installation:	watertable well, 4.5 m deep, slotted 2.5 - 4.5 m, 2" PVC pipe	

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

RED DEER MOTORS LANDFILL
SE 38-27-W4

LOCATION AND SITE DESCRIPTION

- the site, approximately 0.7 ha in area, is located in Red Deer between Red Deer Motors and Waskasoo Creek (Figure 1);
- the site has been reclaimed;
- primarily domestic and possibly some industrial wastes were disposed of at the site.

FIELD PROGRAM

Test Drilling and Monitor Completion

- seven testholes at five sites were drilled (locations shown in Figure 2 and lithologic logs attached);
- five water table wells and two piezometers were installed (completion details contained in Table 1).

EM Survey

- three tansects completed using the EM-31 in the vertical (approximate 3m depth of penetration) and horizontal (approximate 6 m depth of penetration) mode;
- measurement points are 20 m apart.

Monitoring

- water levels recorded on July 16, 1985 (Table 2);
- groundwater and creek samples collected for chemical analysis on July 30, 1985 (Table 3);
- groundwater samples collected from W308 and W312 on September 30, 1985 for GC/MS analysis (analysis resultes attached).

STUDY RESULTS

Geology

- predominant surficial material is till with a clayey to silty texture;

- till contains sand lenses, fine to coarse grained, up to 1.5 m thick;
- surficial material greater than 7.5 m thick;
- the maximum thickness of refuse and fill material is approximately 6 m.

Hydrogeology

- shallow groundwater flow is westward toward Waskasoo Creek (Figure 3);
- water level data from nest P306/W307 indicates that groundwater recharge conditions prevail in the eastern part of the landfill;
- near Waskasoo Creek groundwater discharge conditions prevail (based on water levels from nest P309/W310);
- based on visual grain size analysis, the hydraulic conductivity of the till and sand lenses is in the range 10^{-5} to 10^{-7} cm/s and 10^{-3} to 10^{-5} cm/s, respectively.

EM Survey Results

- the refuse area is characterized by high conductivity values, with the highest values in the north central part of the landfill corresponding to the area of thickest refuse;
- elevated conductivity values in the area of W308 (Figure 4) suggest that contaminants have migrated off-site.

Groundwater Chemistry

- background water is the calcium/magnesium-bicarbonate type with a total dissolved solids concentration <750 mg/L;
- only total hardness and manganese concentrations in background water exceed upper limits for Canadian Drinking Water Standards;
- leachate-contaminated groundwater from the refuse typically is highly mineralized with a high inorganic and organic load;
- high chloride, iron, and C.O.D. levels in groundwater from W308 and 311, indicates that shallow groundwater down-gradient from the landfill is contaminated. Since both holes penetrated saturated sand lenses, it is possible that contaminated groundwater has migrated along these lenses;

- GC/MS analysis of groundwater from W308 and W312 indicate that the organic concentration is low and limited primarily to phthalate esters (plasticizers).

Creek Water Chemistry

- samples of creek water taken upstream and downstream are chemically similar;
- no chemical constituent in either sample exceeds upper limits for Canadian Drinking Water.

CONCLUSIONS

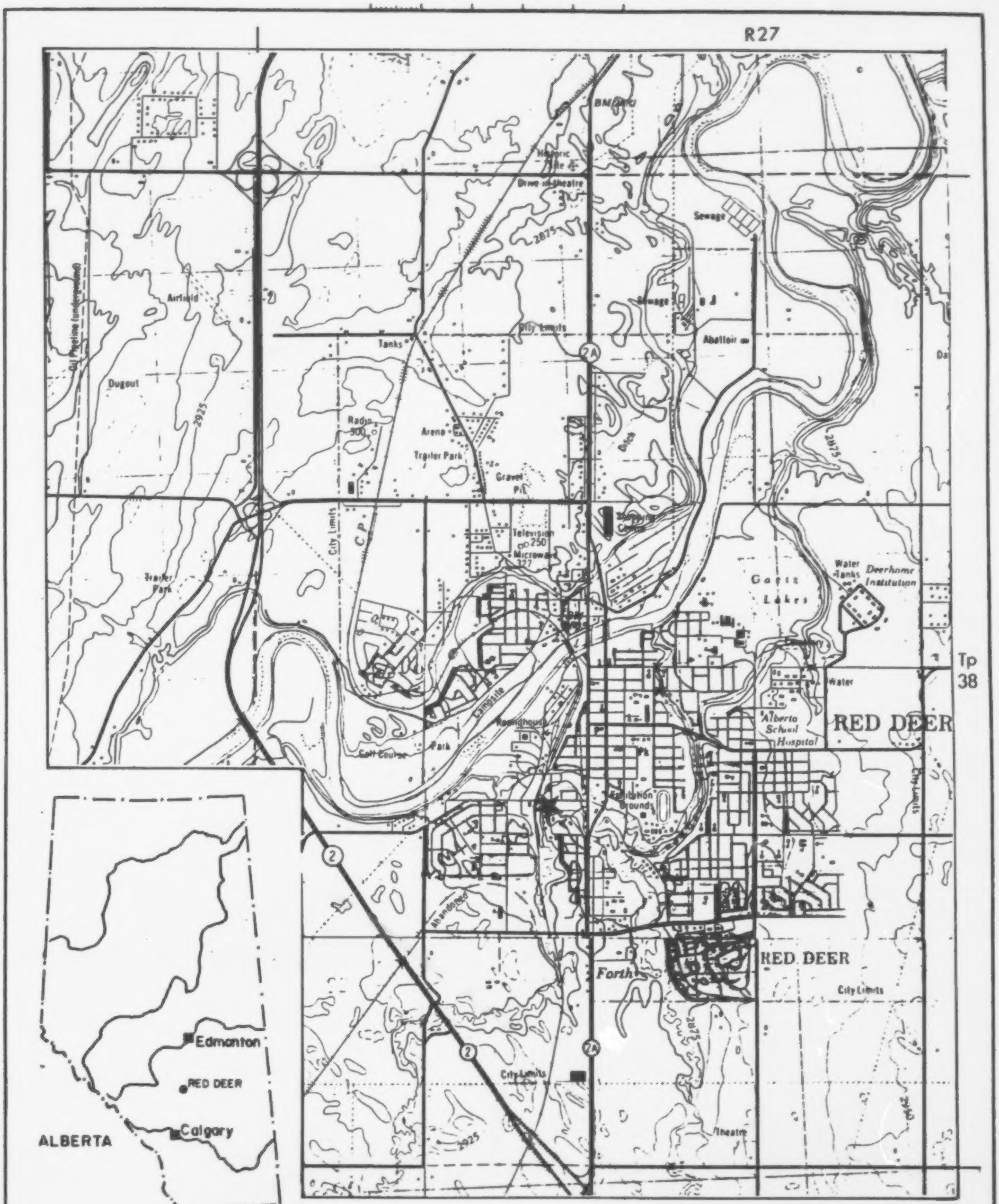
- the movement of contaminants from the landfill is retarded by low permeability till materials. The migration of contaminants along sand layers is limited since they are limited in areal extent;
- creek water has not been polluted by leachate-contaminated groundwater.

RECOMMENDATIONS

- groundwater and creek water quality monitoring should be discontinued;
- site should be down-graded to low priority.

MICROFILM DATE

DRAWING No


R27
Tp 38
Airfield
Oil Pipeline (underground)
Dugout
2925
Trailer Park
Historic Site
Drive-in theatre
2875
Sewage
Sewage
Abattoir
City Limits
Tanks
2A
Radio 300
Arena
Trailer Park
Gravel Pit
Ditch
Shopping Centre
Television 250
Microwave 327
City Limits
C.P.
Gaetz Lakes
Water Tanks
Deerhome Institution
Water
Alberta School Hospital
RED DEER
Campsite
Roundhouse
Golf Course
Park
Exhibition Grounds
2
Abandoned
Forth
RED DEER
City Limits
City Limits
2
2A
City Limits
Theatre
2925
2942
Edmonton
RED DEER
Calgary
ALBERTA

Alberta ENVIRONMENT

SUBMITTED

DATE Feb. 14. 86

APPROVED

DATE Feb. 19/86

DESIGNED

CHECKED

DRAWN

CHECKED

RED DEER RECLAIMED LANDFILL (RED DEER MOTORS)

LOCATION PLAN

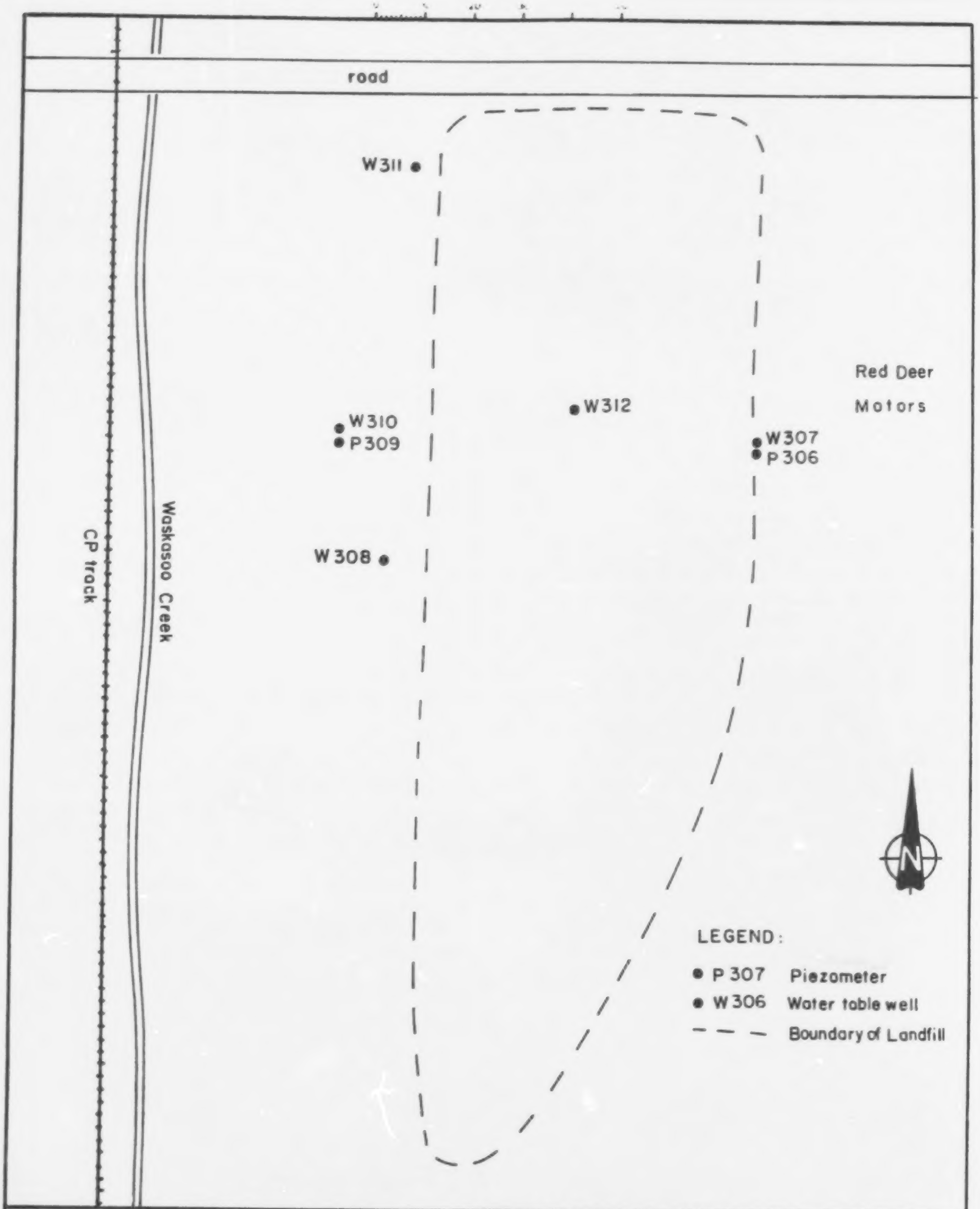
SCALE 1:50000

DATE

SHEET OF

FIGURE No. 1

FILE No


road
W311
W310
P309
W312
W307
P306
W308
Red Deer
Motors
CP track
Waskasoo Creek
N
LEGEND:
● P 307 Piezometer
● W 306 Water table well
— — Boundary of Landfill

Alberta ENVIRONMENT EARTH SCIENCES DIVISION

RED DEER MOTORS RECLAIMED LANDFILL

SITE PLAN

SUBMITTED
DATE Feb. 14/86

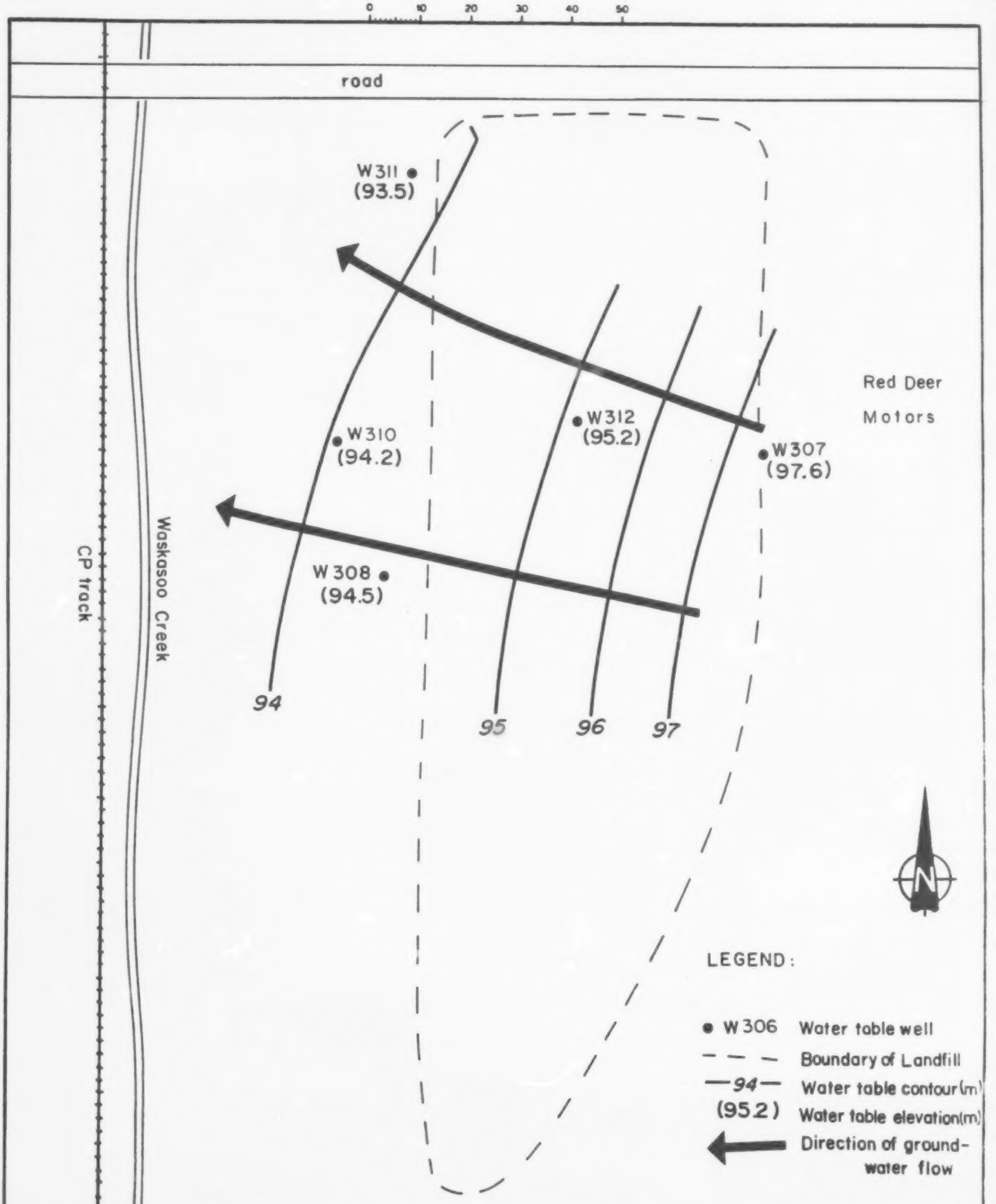
APPROVED
DATE Feb. 14/86

DESIGNED MD
CHECKED

DRAWN MD
CHECKED

SCALE 1:1000
DATE

SHEET OF
FIGURE No. 2


0
10
20
30
40
50
road
W311
(93.5)
W310
(94.2)
W312
(95.2)
W307
(97.6)
W 308
(94.5)
Red Deer
Motors
CP track
Waskasoo Creek
94
95
96
97
N
LEGEND:
W 306 Water table well
Boundary of Landfill
—94— Water table contour (m)
(95.2) Water table elevation (m)
Direction of ground-water flow

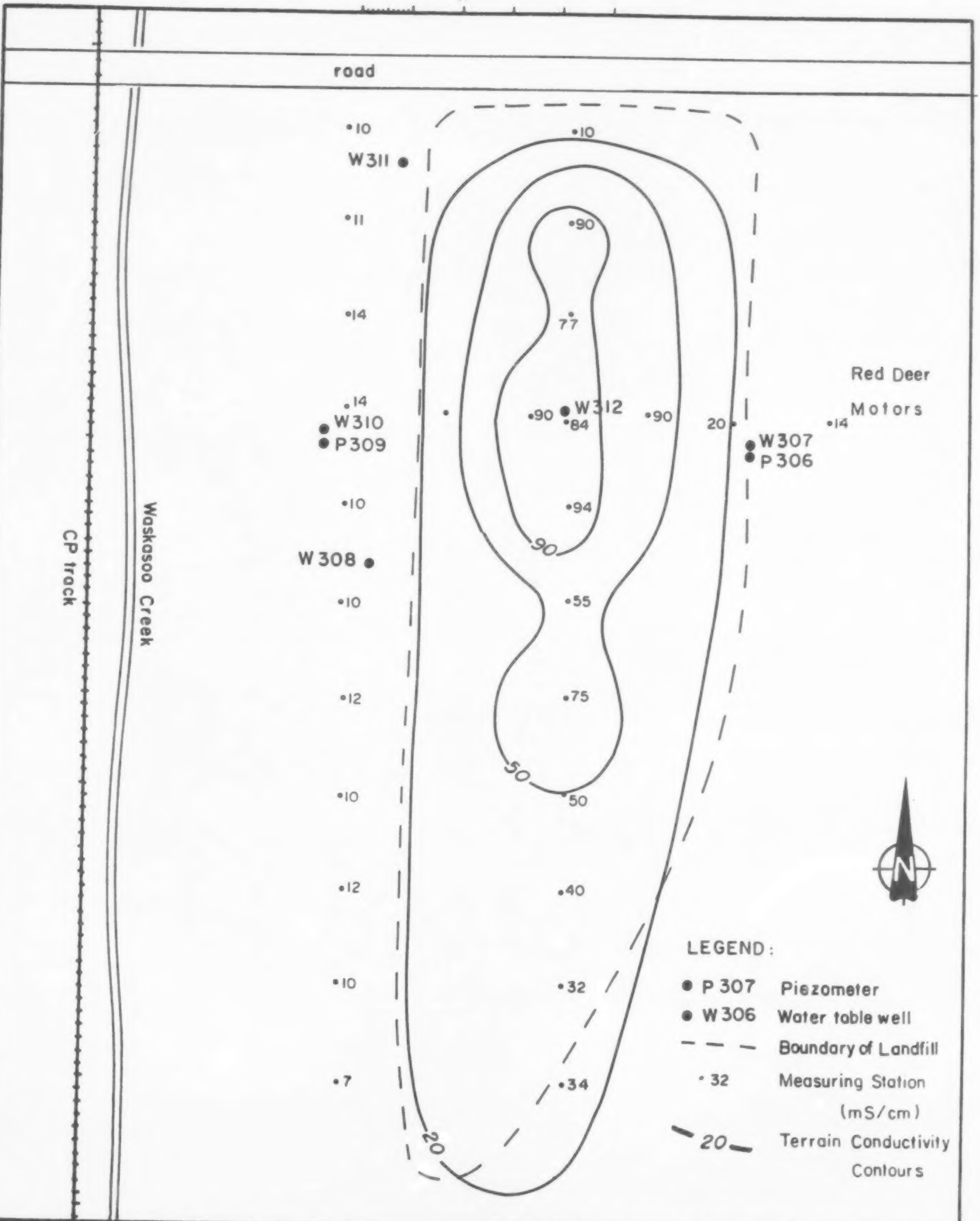
Alberta ENVIRONMENT EARTH SCIENCES DIVISION

RED DEER MOTORS RECLAIMED LANDFILL

WATER TABLE CONTOURS

(July 16, 1985)

SUBMITTED W. J. DATE Feb. 14/86	DESIGNED WC CHECKED	SCALE 1:1000	SHEET OF
APPROVED DATE Feb. 14/86	DRAWN MD CHECKED	DATE	FIGURE No. 3


road
CP track
Waskasoo Creek
Red Deer Motors
W311
W310
P309
W308
W312
W307
P306
•10
•11
•14
•14
•10
•10
•12
•10
•12
•10
•7
•10
•90
77
•90
•84
•90
20
•14
•94
•55
•75
50
•40
•32
•34
90
50
20
N
LEGEND:
● P 307 Piezometer
● W 306 Water table well
— — Boundary of Landfill
• 32 Measuring Station (mS/cm)
20 Terrain Conductivity Contours

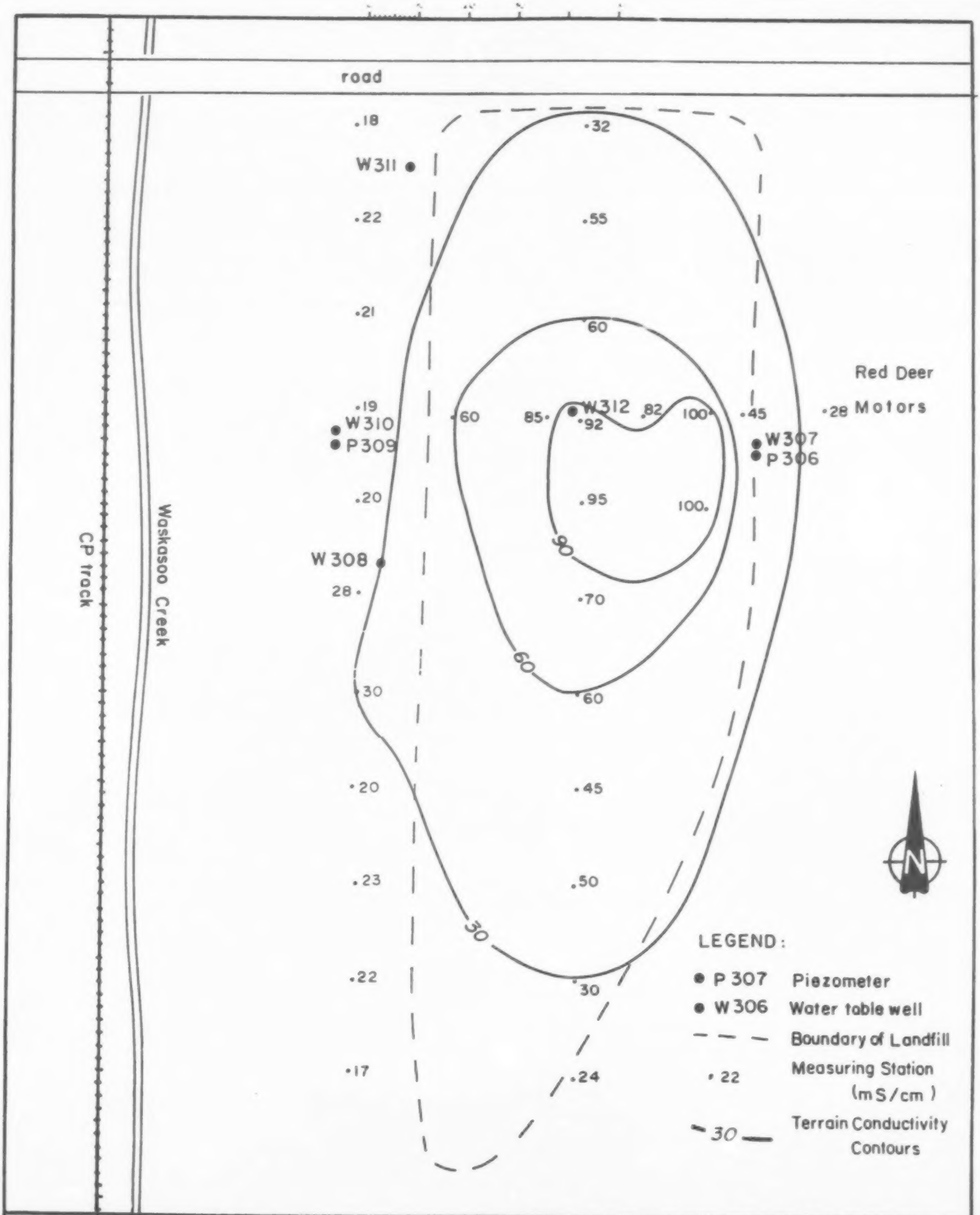
Alberta EARTH SCIENCES DIVISION
ENVIRONMENT

SUBMITTED	DESIGNED MD
DATE Feb. 14. 85	CHECKED
APPROVED	DRAWN MD
DATE Feb. 14/86	CHECKED

RED DEER MOTORS RECLAIMED LANDFILL

TERRAIN CONDUCTIVITY (mS/cm)
approx. 3 m below ground level

SCALE 1:1000	SHEET OF
DATE	FIGURE No. 4


road
CP track
Waskasoo Creek
Red Deer Motors
W311
W310
P309
W308
W312
W307
P306
.18
.22
.21
.19
.20
28
30
.20
.23
.22
.17
.32
.55
60
60
85
.92
.82
100
.45
.28
.95
100
90
.70
60
60
.45
.50
30
30
.24
LEGEND:
● P 307 Piezometer
● W 306 Water table well
— — Boundary of Landfill
• 22 Measuring Station (mS/cm)
30 Terrain Conductivity Contours
N

Alberta ENVIRONMENT EARTH SCIENCES DIVISION

SUBMITTED DATE Feb. 14/86	DESIGNED MD CHECKED	**RED DEER MOTORS RECLAIMED LANDFILL**	
		TERRAIN CONDUCTIVITY (mS/cm) approx. 6m below ground level	
APPROVED DATE Feb 14/86	DRAWN MD CHECKED	SCALE 1:1000 DATE	SHEET OF FIGURE No. 5

TABLE 1: MONITORING WELL COMPLETION INFORMATION

Well Number	Date Installed	Well Depth (m)	Height of pipe above ground surface (m)	Screened interval (m)	Ground elevation (m)	Elevation of pipe (m)
P306	10 7 85	7.5	.82	7.0 - 7.5	101.54	102.36
W307	10 7 85	4.5	.87	1.5 - 4.5	101.54	102.41
W308	10 7 85	4.5	.75	1.5 - 4.5	96.97	97.72
P309	10 7 85	6.0	.92	5.4 - 6.0	95.47	96.39
W310	10 7 85	4.5	.93	1.5 - 4.5	95.47	96.40
W311	10 7 85	4.5	.89	1.5 - 4.5	95.97	96.86
W312	10 7 85	7.5	.70	3.0 - 7.5	100.00	100.70

TABLE 2: WATER LEVEL DATA (85/07/16)

Well Number	Water Level (m) (below top of casing)	Elevation (m)
P306	4.32	98.04
W307	4.72	97.69
W308	3.14	94.58
P309	2.28	94.11
W310	dry @ 5.2	91.2
W311	3.34	93.52
W312	5.47	95.23

TABLE 3: CHEMICAL ANALYSES RESULTS

	Well Numbers						Creek Up	Creek Down	C.D.W.S.*
	P306	W307	W308	P309	W311	W312			
LAB ANALYSIS - all parameters in Mg/L									
Inorganic									
Ca	122	124	218	53	328	286	59	55	
Mg	43	79	152	18	192	198	34	23	150
K	7	5.9	7	3	6.7	19	4.7	4.3	
Na	21	12	201	252	157	243	30	14	300
Cl	8.8	7	411	4.4	673	514	15	19.5	250
SO_4	46	24	14	185	91	22	70	46	500
HCO_3	604	801	1205	697	1069	1664	331	273	
NH_4-N	0.7	0.07	0.35	0.7	0.14	18	0.42	5	1
NO_3-N	0.3	0.28	<0.07	0.04	<0.07	<0.07	0.35	<0.07	10
Total Hard.	485	540	1180	208	1620	1540	290	235	500
T.D.S.	547	647	1600	860	131	2120	382	302	1000
Metals									
Fe	0.05	0.03	41.4	0.05	0.4	6.4	0.03	0.07	0.3
Mn	1.96	0.07	3.4	0.04	1.5	5	0.07	0.09	0.05
Zn	0.02	0.01	0.03	0.01	0.02	0.02	<0.01	0.01	1.0
Pb	0.03	0.03	0.04	0.02	0.06	0.06	0.02	0.03	5.0
Cu	<0.01	0.01	0.01	<0.01	0.01	0.01	0.01	<0.01	0.05
Organics									
COD	118	15	188	67	131	220	34	10	
Other									
pH	7.5	7.8	7.5	8.0	7.5	6.6	8.3	7.8	
EC(mS/cm)	0.9	1.12	4	1.3	4.5	5.0	0.6	0.5	
S.A.R.	0.4	0.2	2.5	7.6	1.7	2.7	0.8	0.4	

* Canadian Drinking Water Standards

EXTRACTABLE PRIORITY POLLUTANTS **W 308** SAMPLE NO. T540-777

(GC/MS FILE NO. >C0712)

COMPOUND	AMOUNT µg/L
ACID GROUPS	
Benzoic Acid	
4-Chloro-m-cresol	
2-Chlorophenol	
2,4-Dichlorophenol	
2,4-Dimethylphenol	
4,6-Dinitro-o-cresol	
2,4-Dinitrophenol	
Hexadecanoic acid	
2-Nitrophenol	
4-Nitrophenol	
Pentachlorophenol	
Phenol	
2,4,5-Trichlorophenol	
2,4,6-Trichlorophenol	
BASE NEUTRAL GROUP	
Polynuclear Aromatics	
Acenaphthene	
Acenaphthylene	
Anthracene	
Benz(a)anthracene	
Benzo(k)fluoranthene	
Benzo(ghi)perylene	
Benzo(a)pyrene	
Chrysene	
Dibenz(ah)anthracene	
Fluoranthene	
Fluorene	
Indeno(1,2,3-cd)pyrene	
Naphthalene	
Perylene	
Phenanthrene	
Pyrene	

COMPOUND	AMOUNT µg/L
Chloroorganics	
Chlorobenzene	
2-Chloronaphthalene	
1,2-Dichlorobenzene	
1,3-Dichlorobenzene	
1,4-Dichlorobenzene	
Hexachlorobenzene	
Hexachlorobutadiene	
Hexachlorocyclopentadiene	
Hexachloroethane	
1,2,4-Trichlorobenzene	
Nitroaromatics	
Benzidine	
3,3'-Dichlorobenzidine	
2,4-Dinitrotoluene	
2,6-Dinitrotoluene	
1,2-Diphenylhydrazine	
Nitrobenzene	
N-Nitrosodimethylamine	
N-Nitrosodiphenylamine	
N-Nitrosodi-n-propylamine	
Halo Ethers	
4-Bromophenyl phenyl ether	
Bis(2-chloroethoxy)methane	
Bis(2-chloroethyl)ether	
Bis(2-chloroisopropyl)ether	
2-Chloroethyl vinyl ether	
4-Chlorophenyl phenyl ether	
Phthalate Esters	
Butylbenzylphthalate	
Di-n-butylphthalate	
Diethylphthalate	trace
Dimethylphthalate	
Di-n-octylphthalate	
Bis(2-ethylhexyl)phthalate	6.4

Blank spaces indicate less than detection limit.
Detection limit for ACID and BASE NEUTRAL GROUPS <1.0 µg/L
TRACE indicates the compound is observed at less than the detection limit.

OTHER:

1 - 5 µg/L conc. range
isophorone

0.5 - 1.0 µg/L conc. range
methylethenyl benzene
phenyl methyl ketone
alkyl formate, mol wt >250
aceto substituted organic, mol wt >253
benzyl dimethyl alcohol

0.1 - 0.5 µg/L conc. range
$C_{10}H_{12}$ hydrocarbon, mol wt=142
ethylhexene
isocineole
$C_{10}H_{18}O$ isomers, mol wt=154
dimethyl thiophene
organophosphate, mol wt>155
menthanol
fluoromethoxy benzene
ethyldimedone
$C_{10}H_{16}O_2$ cyclohexanedione substituted organics, mol. wt=168
phenylethyl ketone
methyl bis(dimethylethyl)phenol

EXTRACTABLE PRIORITY POLLUTANTS **W 312** SAMPLE NO. T540-778

(GC/MS FILE NO. >C0713)

COMPOUND	AMOUNT µg/L
ACID GROUPS	
Benzoic Acid	
4-Chloro-*m*-cresol	
2-Chlorophenol	
2,4-Dichlorophenol	
2,4-Dimethylphenol	1.7
4,6-Dinitro-*o*-cresol	
2,4-Dinitrophenol	
Hexadecanoic acid	
2-Nitrophenol	trace
4-Nitrophenol	
Pentachlorophenol	
Phenol	trace
2,4,5-Trichlorophenol	
2,4,6-Trichlorophenol	
BASE NEUTRAL GROUP	
Polynuclear Aromatics	
Acenaphthene	
Acenaphthylene	trace
Anthracene	
Benz(a)anthracene	
Benzo(k)fluoranthene	
Benzo(ghi)perylene	
Benzo(a)pyrene	
Chrysene	
Dibenz(ah)anthracene	
Fluoranthene	
Fluorene	
Indeno(1,2,3-cd)pyrene	
Naphthalene	trace
Perylene	
Phenanthrene	
Pyrene	

COMPOUND	AMOUNT µg/L
Chloroorganics	
Chlorobenzene	
2-Chloronaphthalene	
1,2-Dichlorobenzene	
1,3-Dichlorobenzene	
1,4-Dichlorobenzene	
Hexachlorobenzene	
Hexachlorobutadiene	
Hexachlorocyclopentadiene	
Hexachloroethane	
1,2,4-Trichlorobenzene	
Nitroaromatics	
Benzidine	
3,3'-Dichlorobenzidine	
2,4-Dinitrotoluene	
2,6-Dinitrotoluene	
1,2-Diphenylhydrazine	
Nitrobenzene	
N-Nitrosodimethylamine	
N-Nitrosodiphenylamine	
N-Nitrosodi-*n*-propylamine	
Halo Ethers	
4-Bromophenyl phenyl ether	
Bis(2-chloroethoxy)methane	
Bis(2-chloroethyl)ether	trace
Bis(2-chloroisopropyl)ether	
2-Chloroethyl vinyl ether	
4-Chlorophenyl phenyl ether	
Phthalate Esters	
Butylbenzylphthalate	
Di-*n*-butylphthalate	trace
Diethylphthalate	12
Dimethylphthalate	trace
Di-*n*-octylphthalate	
Bis(2-ethylhexyl)phthalate	20

Blank spaces indicate less than detection limit.
Detection limit for ACID and BASE NEUTRAL GROUPS <1.0 µg/L
TRACE indicates the compound is observed at less than the detection limit.

OTHER:

1 - 10 µg/L conc. range
isophorone

$C_6H_{10}O$ isomer mol wt=98
methylcyclohexanone
dimethyl hexene
ethylmethyl benzene
trimethyl benzene
dimethyl benzyl alcohol
aromatic alcohol, mol wt≥138
isocineole
C_9H_{12} isomer, mol wt=120
$C_{10}H_{14}$ alkyl benzene, mol wt=134
cineole
bicyclohexyl substituted organic, mol. wt=152
menthanol
methyl nonanediol
$C_{10}H_{16}O_2$ organic, mol wt=168
tetramethyl cyclohexanedione
iso-butyl toluate
alkyl formate, mol wt ≥ 250

10 - 50 µg/L conc. range
camphor
$C_{10}H_{14}O_2$ dione, mol. wt=166
aceto substituted organic, mol wt≥253

SOILS BRANCH DRILL HOLE LOG

Land Location SE Sec. 8 Tp. 38 R. 27 W 4

Date July 10, 1985 Supervisor W.J. Ceroici

Project Red Deer Motors Landfill - Groundwater Monitoring

Test Hole P306 to W312 inclusive.

Test Hole P306

DEPTH (m)	DESCRIPTION	Moisture Content*
0 - 1.5	fill, silty clay, dark brown, friable	d
1.5 - 3.0	till, silty clay, brown, firm, oxidized and carbonaceous streaks	sm
3.0 - 4.5	as above, more sandy	sm
4.5 - 6.0	till, sandy clay, brown, some coarse sand	s
6.0 - 7.0	sand, brown, medium to coarse grained	s
7.0 - 7.5	till, sandy clayey, dark brown, small pebbles, firm	s

Completion: Hole sloughed in to 6 m
Screened interval 5.5 to 6 m below ground level

Test Hole W307

0 - 4.5	as in P306

Completion: slotted pipe 1.5 - 4.5 m below ground level

*M.C. (Moisture Content): d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole W308		
0 - 0.5	topsoil, dark brown, loose	d
0.5 - 1.5	clay, light brown, silty, occasional pebbles, firm	d
1.5 - 2.0	gravel?, difficult drilling few returns	d
2.0 - 2.5	clay, light brown, silty, pebbles	sm - vm
2.5 - 4.0	sand, grey, fine grained; silty layers	s
4.0 - 4.5	clay, dark brown, sandy, firm, some pebbles	vm
Completion:	slotted 1.5 - 4.5 m below ground level	
Test Hole P309		
0 - 0.5	topsoil, dark brown, loose	d
0.5 - 3.0	till, brown, silty, minor pebbles, sand streaks	d
3.0 - 4.5	till, grey-brown, silty, firm	sm - vm
4.5 - 6.0	sand, grey, fine grained, silty layers	s
Completion:	Screened interval 5.5 to 6 m below ground level	
Test Hole W310		
0 - 4.5	as above	
Completion:	Slotted interval 1.5 - 4.5 m	

*M.C. (Moisture Content): d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole W311		
0 - 1.0	topsoil, dark brown	d
1.0 - 2.0	till, brown, clayey, sand streaks, firm	m
2.0 - 3.0	sand, grey, fine grained, oxidized streaks	s
3.0 - 4.5	till, dark brown, clayey, some pebbles, firm	vm
Completion: Slotted interval 1.5 - 4.5 m below ground level		
Test Hole W312		
0 - 0.5	topsoil, dark brown	d
0.5 - 5.5	refuse and fill	d - s
5.5 - 7.5	till, grey, contains pebbles, firm	vm
Completion: Slotted interval 3.0 - 7.5 m below ground level		

*M.C. (Moisture Content): d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

RED DEER (SEWAGE TREATMENT PLANT) LANDFILL

NW 34-38-27-W4

LOCATION AND SITE DESCRIPTION

- the site, 2 ac (0.8 ha) in area, is located adjacent to the City of Red Deer Sewage Treatment Plant (Figure 1);
- the site which has been reclaimed, was at one time a sand and gravel pit;
- domestic and possibly industrial refuse was disposed of at the site.

FIELD PROGRAM

Test Drilling and Monitor Completion

- five testholes drilled (locations shown in Figure 2 and borehole logs attached);
- four water table wells installed (completion details in Table 1).

EM Survey

- five transects completed using the EM-31 in the vertical (3 m depth and horizontal (6 m depth) mode (Figure 3 and 4);
- the spacing between measurement points was 10 and 20 m.

Monitoring

- water levels recorded on July 16, 1985 (Table 2);
- groundwater and river samples collected for chemical analysis on July 30, 1985 (Table 3);
- groundwater samples collected from wells 315 and 317 on September 30, 1985 for GC/MS analysis (analysis results attached).

STUDY RESULTS

Geology

- in the vicinity of the landfill, sand and sand and gravel overlie shale bedrock. West of the landfill, till separates sand and gravel from the bedrock;
- clay fill and garbage up to 7 m thick overlies shale (Figure 5);
- shallow bedrock may be fractured.

Hydrogeology

- shallow groundwater flow is eastward toward the Red Deer River (Figure 5);
- the depth to the water table is approximately 4 m below ground surface;
- shallow groundwater system hydraulically connected to river;
- hydraulic conductivity of sand, and sand and gravel approximately 10^{-3} cm/s.

EM Survey Results

- background conductivity values are approximately 4 and 10 mS/cm, for the 3 m and 6 m depths, respectively;
- the refuse area is characterized by high conductivity values, with the highest values near the intersection of Lines 2 and 4.
- sections of line 5, between the landfill and river, have elevated conductivity values. This suggests shallow groundwater, down-gradient from the landfill, has been contaminated.

Groundwater Chemistry

- background groundwater is predominantely the calcium-magnesium/ bicarbonate type with a total dissolved solids concentration <1000 mg/L;
- the total hardness, iron and manganese concentrations in background water exceed the upper limit for Canadian Drinking Water;
- leachate-contaminated groundwater from 317, completed in the most contaminated area of the landfill (based on EM survey), has elevated concentrations of sodium, chloride, ammonium, total hardness, iron, manganese and lead;
- groundwater from 315, located down-gradient from the landfill, tends to be more mineralized than background water with a high chloride concentration indicating that it is contaminated;
- a high COD in groundwater from 315 and 317 indicates that leachate and leachate-contaminated groundwater has a high organic load;

- detailed organic analysis by GC/MS indicates organics are predominantly phenolic compounds, naphthalene and phthalate esters, which suggests industrial wastes were disposed of in the landfill;
- phenolic compounts account for the iridescent sheen on a stagnant pool in the river, immediately east of 315;
- the concentration of phenolic compounds in groundwater from both 315 and 317 exceeds the upper limit of 2 ug/L for Canadian Drinking Water.

Red Deer River Water Chemistry

- water upstream from the landfill is the calcium/magnesium-bicarbonate type with a total dissolved concentration <200 mg/L;
- water from a stagnant pool in the river, east of 315, is slightly more mineralized than upstream water;
- more mineralized water plus the iridescent sheen on the pool suggests that it has been contaminated;
- the low C.O.D. suggests a low organic content in both samples from the river.

CONCLUSIONS

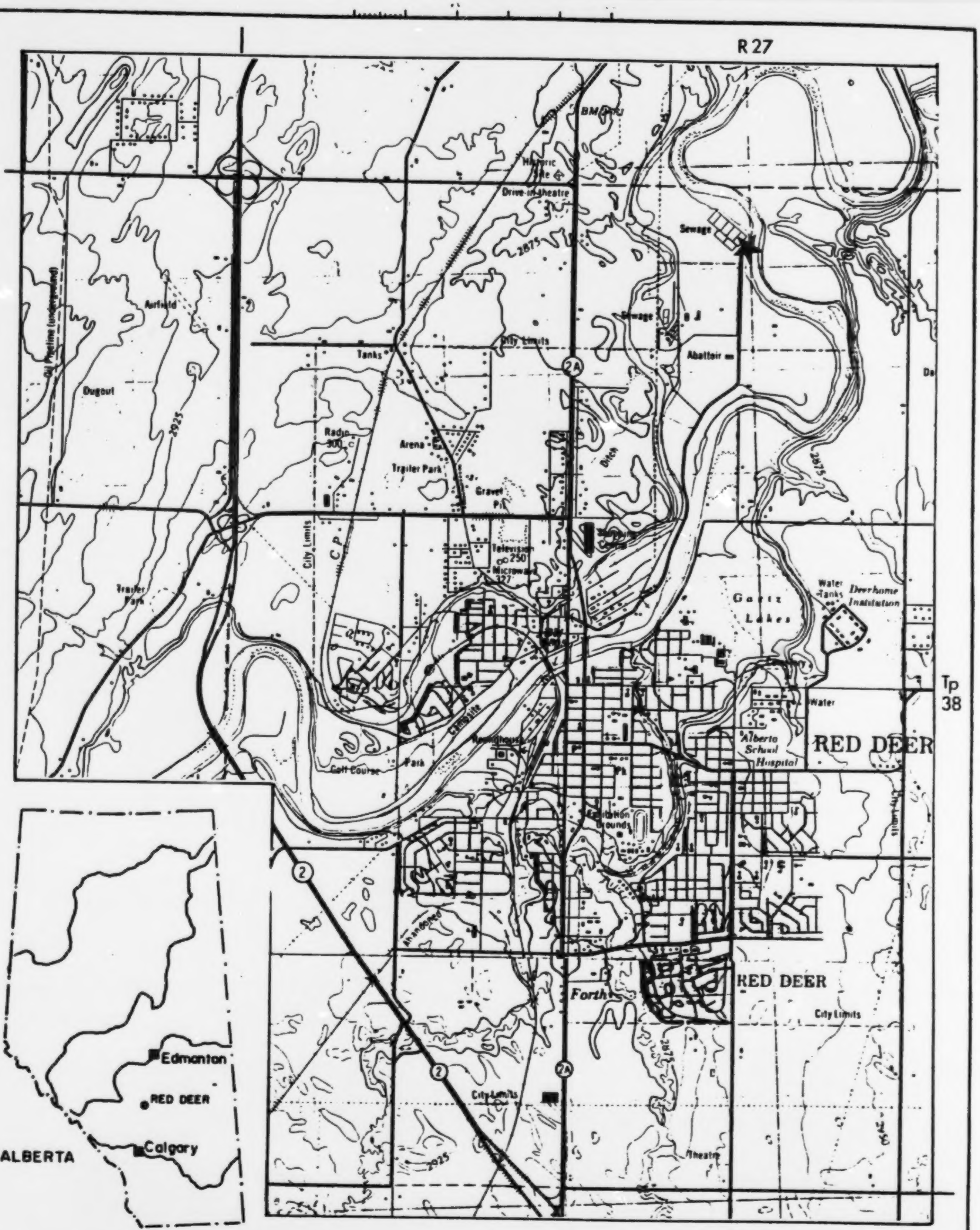
- groundwater down-gradient from the landfill is contaminated with inorganic and organic compounds;
- the discharge of this groundwater into the river has resulted in minor contamination of water in stagnant pools in the river (esp. east of 315); however, no contamination was detected in the main part of the river;
- no inorganic constituents in water from the river exceed upper limits for Canadian Drinking Water Standards.

RECOMMENDATIONS

- collect samples of river water in 1986 for analysis and subject one sample to detailed analysis for organics using GC/MS;
- it is recommended that accurate hydraulic conductivity data be acquired for the sand and gravel and shallow bedrock to facilitate calculation of the groundwater discharge rate into the river.

MICROFILM DATE

DRAWING No



R 27
Tp 38
BM
Historic Site
Drive-in theatre
2875
Sewage
Airfield
Oil Pipeline (underground)
Sewage
City Limits
Tanks
Abattoir
2A
Dugout
2925
Radio 300
Arena
Trailer Park
Gravel Pit
Ditch
Shopping Centre
City Limits
CP
Television 250
Microwave 327
Trailer Park
Water Tanks
Deerhome Institution
Gaetz Lakes
Water
Alberta School Hospital
RED DEER
Golf Course
Park
Campsite
Roundhouse
Exhibition Grounds
2
Abandoned
RED DEER
Forth
City Limits
City Limits
2925
Theatre
Edmonton
RED DEER
Calgary
ALBERTA

Alberta
ENVIRONMENT

RED DEER RECLAIMED LANDFILL (SEWERAGE)

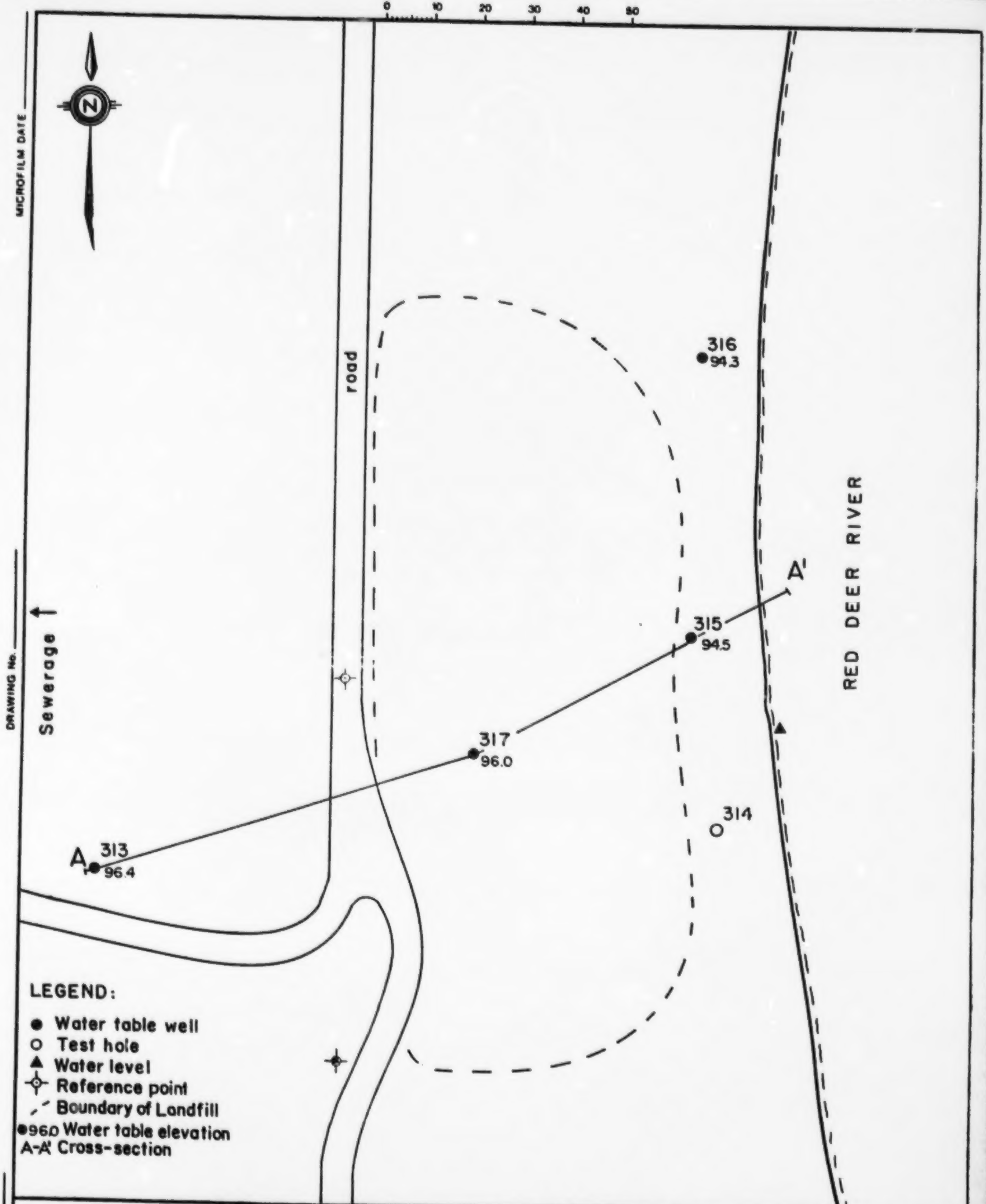
LOCATION PLAN

SUBMITTED W. J.
DATE Feb. 14/86
APPROVED
DATE Feb. 14/86
DESIGNED
CHECKED
DRAWN
CHECKED
SCALE 1:50000
DATE
SHEET OF
FIGURE No. 1

FILE No.

MICROFILM DATE

DRAWING No.


0
10
20
30
40
50
N
road
Sewerage
RED DEER RIVER
316
94.3
315
94.5
A'
317
96.0
314
A
313
96.4
LEGEND:
● Water table well
○ Test hole
▲ Water level
Reference point
Boundary of Landfill
●96.0 Water table elevation
A-A' Cross-section

Alberta
ENVIRONMENT

RED DEER SEWAGE PLANT RECLAIMED DUMP

SITE PLAN

SUBMITTED W. J. Gun	DESIGNED M.D.
DATE Feb. 14/86	CHECKED
APPROVED J. McCracken	DRAWN M.D.
DATE Feb. 14/86	CHECKED

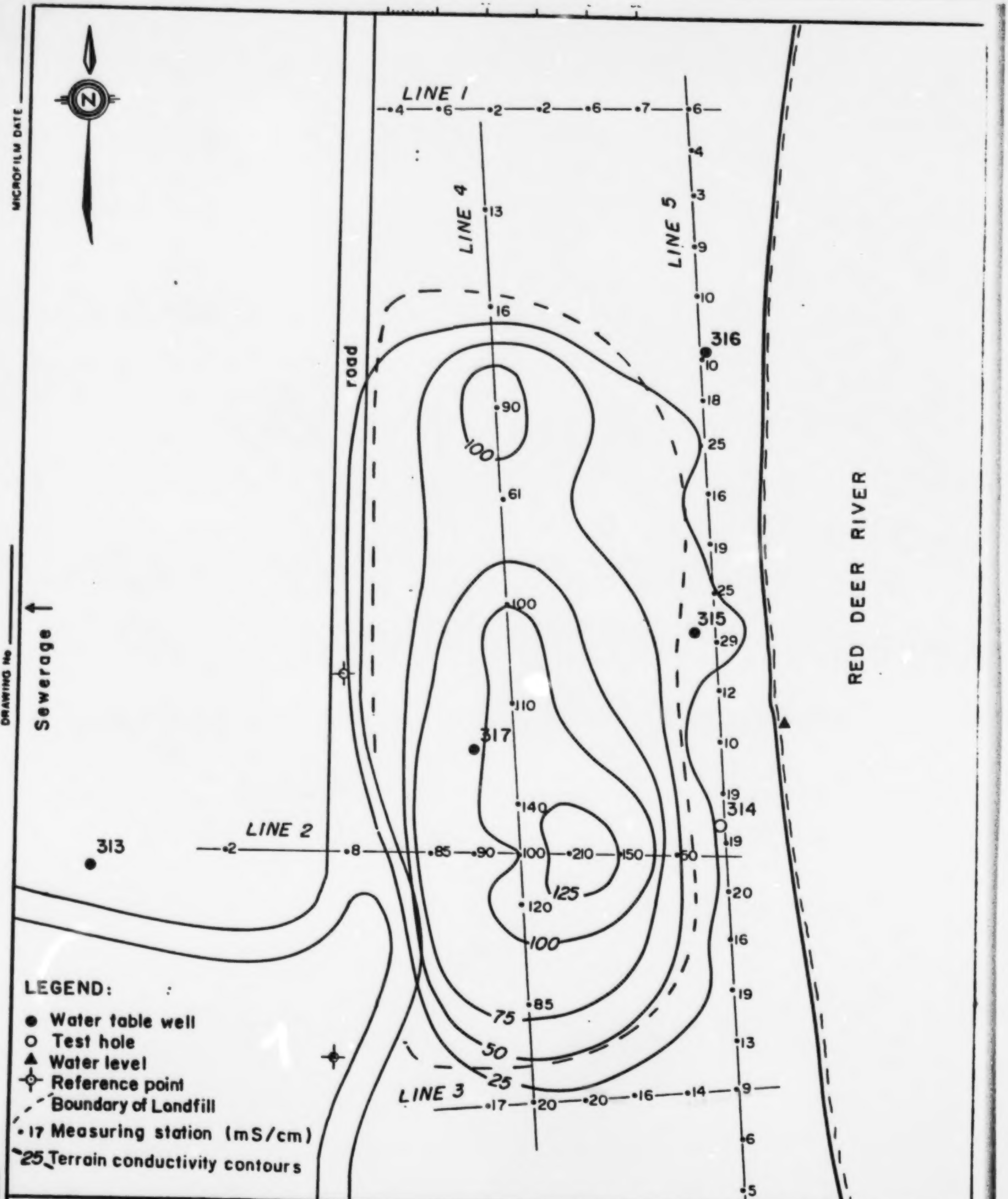
SCALE 1= 1000

DATE

SHEET OF

FIGURE No. 2

FILE No.


MICROFILM DATE
DRAWING No
LINE 1
4
6
2
2
6
7
6
4
3
9
10
LINE 4
LINE 5
13
16
316
10
18
25
16
19
25
315
29
12
10
19
314
19
20
16
19
13
9
6
5
90
100
61
100
110
317
140
LINE 2
313
2
8
85
90
100
210
150
50
125
120
100
85
75
50
25
LINE 3
17
20
20
16
14
road
Sewerage
RED DEER RIVER
N
LEGEND:
Water table well
Test hole
Water level
Reference point
Boundary of Landfill
17 Measuring station (mS/cm)
25 Terrain conductivity contours

Alberta
ENVIRONMENT

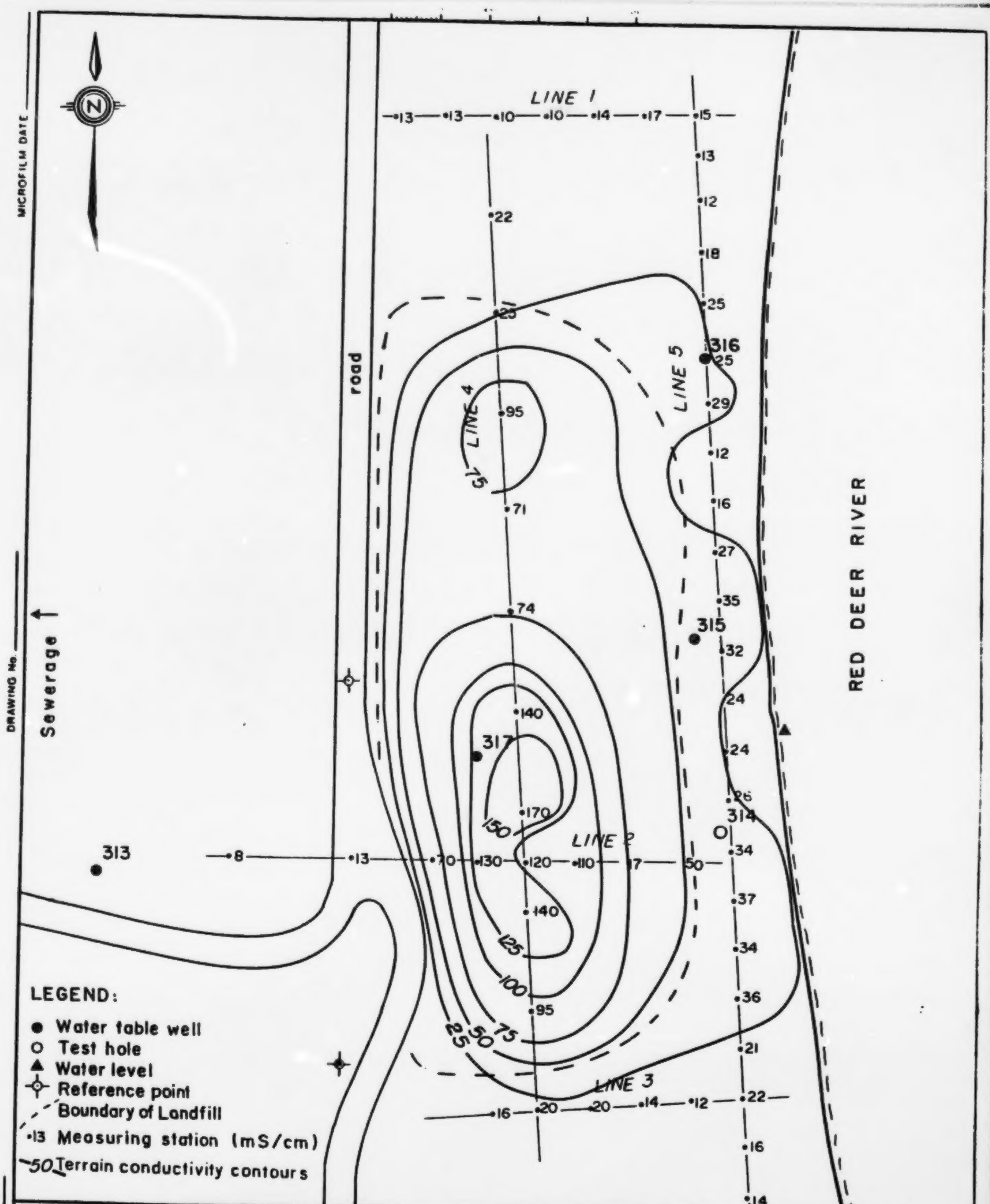
SUBMITTED
DATE Feb. 14. 86
APPROVED
DATE Feb. 14/86
DESIGNED M.D.
CHECKED
DRAWN M.D.
CHECKED

RED DEER SEWAGE PLANT RECLAIMED DUMP

TERRAIN CONDUCTIVITY
approx. 3 m below ground level

SCALE 1= 1000
DATE
SHEET OF
FIGURE No.3

FILE No.


N
LINE 1
13
13
10
10
14
17
15
13
12
18
25
22
25
road
LINE 4
LINE 5
316
25
95
29
75
12
16
71
27
74
35
315
32
Sewerage
RED DEER RIVER
140
24
317
24
26
170
314
150
LINE 2
313
8
13
70
130
120
110
17
50
34
140
37
125
34
100
36
95
75
50
25
21
LINE 3
16
20
20
14
12
22
16
14
LEGEND:
● Water table well
○ Test hole
▲ Water level
Reference point
Boundary of Landfill
•13 Measuring station (mS/cm)
50 Terrain conductivity contours

MICROFILM DATE

DRAWING No.

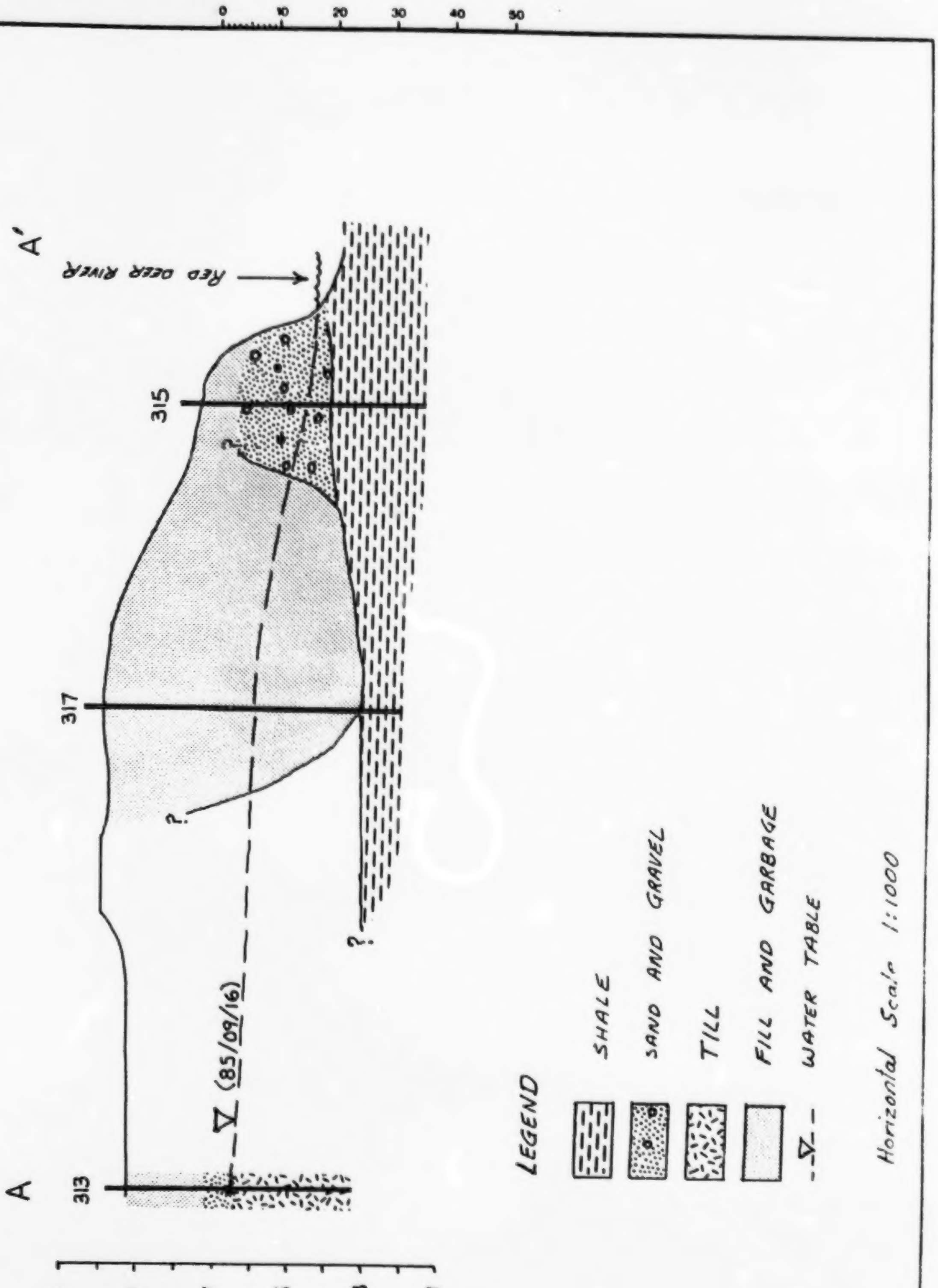
FILE No.

Alberta
ENVIRONMENT

SUBMITTED *W. J. Gerain*	DESIGNED M.D.	**RED DEER SEWAGE PLANT RECLAIMED DUMP**	
DATE *Feb. 14/86*	CHECKED	TERRAIN CONDUCTIVITY approx. 6 m below ground level	
APPROVED *Z. J. McCracken*	DRAWN M.D.	SCALE 1= 1000	SHEET OF
DATE *Feb. 14/86*	CHECKED	DATE	FIGURE No. 4

MICROFILM DATE

DRAWING No



0
10
20
30
40
50
A
A'
313
317
315
RED DEER RIVER
?
?
?
▽ (85/09/16)
101
99
97
95
93
91
Elevation (m)
LEGEND
SHALE
SAND AND GRAVEL
TILL
FILL AND GARBAGE
WATER TABLE
Horizontal Scale 1:1000

Alberta
ENVIRONMENT

SUBMITTED
DATE Feb. 14/86

APPROVED
DATE Feb. 14/86

DESIGNED W.C.
CHECKED

DRAWN W.C.
CHECKED

RED DEER RECLAIMED LANDFILL (SEWERAGE)

GEOLOGICAL CROSS SECTION

SCALE
DATE

SHEET OF
FIGURE No.5

FILE No.

TABLE 1: MONITORING WELL COMPLETION INFORMATION

Well Number	Date Installed	Well Depth (m)	Height of pipe above ground surface (m)	Screened interval (m)	Ground elevation (m)	Elevation of pipe (m)
W313	10 7 85	4.5	.85	2.5 - 4.5	99.17	100.02
W315	10 7 85	6.0	.80	3.0 - 6.0	97.41	98.21
W316	10 7 85	6.0	.77	3.0 - 6.0	96.78	97.55
W317	10 7 85	7.5	.96	4.5 - 7.5	100.00	100.96
River					94.50	
314					96.78	

TABLE 2: WATER LEVEL DATA (85/07/16)

Well Number	Water Level (m) (below top of casing)	Elevation (m)
313	3.63	96.4
315	3.73	94.5
316	3.23	94.3
317	4.92	96.0

TABLE 3: CHEMICAL ANALYSIS RESULTS

	Well Numbers				River Upstream	Pool in River	C.D.W.S.
	313	315	316	317			
LAB ANALYSIS - all parameters in mg/L							
Inroganic							
Ca	141	320	124	136	41	55	
Mg	68	139	41	118	15	23	150
K	11.7	11	9	231	0.8	4.3	
Na	48.5	127	99	570	4.6	14	300
Cl	69	354	97.5	635	1.8	19.5	250
SO_4	142	7.2	24	34	41	46	500
HCO_3	629	1340	686	2912	155	273	
NH_4-N	1.3	0.4	0.8	322	<0.07	4.7	1
NO_3-N	0.14	<0.07	<0.07	<0.14	<0.07	<0.07	10
Total Hard.	630	1370	480	830	165	235	500
T.D.S.	792	1620	733	3570	186	302	1000
Metals							
Fe	0.21	0.5	0.14	130	0.03	0.07	0.3
Mn	8.4	1.0	0.84	0.82	0.02	0.09	0.05
Cu	0.01	0.01	0.01	0.01	<0.01	<0.01	1.0
Zn	0.02	0.04	0.01	0.24	<0.01	0.01	5.0
Pb	0.03	0.05	0.03	0.07	0.02	0.03	0.05
Organics							
COD	47	237	25	1790	15	10	
Other							
pH	7.6	7.45	7.5	7.0	8.3	7.8	
EC(mS/cm)	1.2	4.0	1.1	8.5	0.3	0.5	
S.A.R.	0.8	1.5	2.0	8.6	0.2	0.4	

*Canadian Drinking Water Standards

EXTRACTABLE PRIORITY POLLUTANTS

SAMPLE NO. T540-779

(GC/MS FILE NO. >C0714)

COMPOUND	AMOUNT µg/L	COMPOUND	AMOUNT µg/L
ACID GROUPS		Chloroorganics	
Benzoic Acid		Chlorobenzene	
4-Chloro-*m*-cresol		2-Chloronaphthalene	trace
2-Chlorophenol		1,2-Dichlorobenzene	
2,4-Dichlorophenol		1,3-Dichlorobenzene	
2,4-Dimethylphenol	trace	1,4-Dichlorobenzene	
4,6-Dinitro-*o*-cresol		Hexachlorobenzene	
2,4-Dinitrophenol		Hexachlorobutadiene	
Hexadecanoic acid		Hexachlorocyclopentadiene	
2-Nitrophenol		Hexachloroethane	
4-Nitrophenol		1,2,4-Trichlorobenzene	
Pentachlorophenol		Nitroaromatics	
Phenol	12	Benzidine	
2,4,5-Trichlorophenol		3,3'-Dichlorobenzidine	
2,4,6-Trichlorophenol		2,4-Dinitrotoluene	
		2,6-Dinitrotoluene	
BASE NEUTRAL GROUP		1,2-Diphenylhydrazine	
Polynuclear Aromatics		Nitrobenzene	
Acenaphthene		N-Nitrosodimethylamine	
Acenaphthylene		N-Nitrosodiphenylamine	
Anthracene		N-Nitrosodi-*n*-propylamine	
Benz(a)anthracene		Halo Ethers	
Benzo(k)fluoranthene		4-Bromophenyl phenyl ether	
Benzo(ghi)perylene		Bis(2-chloroethoxy)methane	
Benzo(a)pyrene		Bis(2-chloroethyl)ether	
Chrysene		Bis(2-chloroisopropyl)ether	
Dibenz(ah)anthracene		2-Chloroethyl vinyl ether	
Fluoranthene		4-Chlorophenyl phenyl ether	
Fluorene		Phthalate Esters	
Indeno(1,2,3-cd)pyrene		Butylbenzylphthalate	
Naphthalene	4.2	Di-*n*-butylphthalate	
Perylene		Diethylphthalate	8.0
Phenanthrene		Dimethylphthalate	
Pyrene		Di-*n*-octylphthalate	
		Bis(2-ethylhexyl)phthalate	43
		Dimethoxy ethyl phthalate	5.2

Blank spaces indicate less than detection limit.
Detection limit for ACID and BASE NEUTRAL GROUPS <1.0 µg/L
TRACE indicates the compound is observed at less than the detection limit.

OTHER:

5 - 10 µg/L conc. range
S_8 elemental sulphur
isophorone
ethylmethyl benzenes
trimethyl benzenes
dihydroindene
methylphenyl ketone
$C_{10}H_{14}$ alkyl benzenes, mol wt=134
menthanol

1 - 5 µg/L conc. range
organophosphate, mol. wt$\geq$182
alkyl benzenes, $C_{10}H_{12}$ mol. wt=132
methyl naphthalenes
benzene acetic acid, ethyl ester
dimethyl naphthalene
S_6 elemental sulphur
S_7 elemental sulphur
isotoluic acid, isobutyl ester
aceto substituted organics, mol. wt$\geq$166

EXTRACTABLE PRIORITY POLLUTANTS SAMPLE NO. T540-780

(GC/MS FILE NO. >C0715)

COMPOUND	AMOUNT µg/L
ACID GROUPS	
Benzoic Acid	
4-Chloro-*m*-cresol	
2-Chlorophenol	
2,4-Dichlorophenol	
2,4-Dimethylphenol	
4,6-Dinitro-*o*-cresol	
2,4-Dinitrophenol	1.2
Hexadecanoic acid	trace
2-Nitrophenol	
4-Nitrophenol	
Pentachlorophenol	
Phenol	2.8
2,4,5-Trichlorophenol	
2,4,6-Trichlorophenol	
BASE NEUTRAL GROUP	
Polynuclear Aromatics	
Acenaphthene	
Acenaphthylene	trace
Anthracene	
Benz(a)anthracene	
Benzo(k)fluoranthene	
Benzo(ghi)perylene	
Benzo(a)pyrene	
Chrysene	
Dibenz(ah)anthracene	
Fluoranthene	
Fluorene	
Indeno(1,2,3-cd)pyrene	
Naphthalene	trace
Perylene	
Phenanthrene	
Pyrene	

COMPOUND	AMOUNT µg/L
Chloroorganics	
Chlorobenzene	
2-Chloronaphthalene	
1,2-Dichlorobenzene	
1,3-Dichlorobenzene	trace
1,4-Dichlorobenzene	
Hexachlorobenzene	
Hexachlorobutadiene	
Hexachlorocyclopentadiene	
Hexachloroethane	
1,2,4-Trichlorobenzene	
Nitroaromatics	
Benzidine	
3,3'-Dichlorobenzidine	
2,4-Dinitrotoluene	trace
2,6-Dinitrotoluene	
1,2-Diphenylhydrazine	
Nitrobenzene	
N-Nitrosodimethylamine	
N-Nitrosodiphenylamine	
N-Nitrosodi-*n*-propylamine	
Halo Ethers	
4-Bromophenyl phenyl ether	
Bis(2-chloroethoxy)methane	
Bis(2-chloroethyl)ether	trace
Bis(2-chloroisopropyl)ether	
2-Chloroethyl vinyl ether	
4-Chlorophenyl phenyl ether	
Phthalate Esters	
Butylbenzylphthalate	3.1
Di-*n*-butylphthalate	14
Diethylphthalate	62
Dimethylphthalate	
Di-*n*-octylphthalate	
Bis(2-ethylhexyl)phthalate	5.9
Dicyclohexyl phthalate	trace

Blank spaces indicate less than detection limit.
Detection limit for ACID and BASE NEUTRAL GROUPS <1.0 µg/L
TRACE indicates the compound is observed at less than the detection limit.

OTHER:

10- 50 µg/L conc. range
camphor
aceto organanic, mol. wt>160
benzene propanoic acid
phenylethyl phenol

0.5 - 1.0 µg/L conc. range
isophorone
methyl phenols
hexadecanoic acid

1 - 10 µg/L conc. range
benzaldehyde
butanoic acid
aliphatic acid, mol. wt>104
C_9H_{12} alkyl benzenes, mol. wt=120
$C_{10}H_{16}$ isomers, mol. wt=136
$C_{10}H_{14}$ alkyl benzenes, mol. wt=134
$C_{10}H_{18}$ alkyl substituted cyclohexane, mol. wt=138
alkylphosphate, mol. >212
propyl substituted benzothiazole, mol. wt>238
aliphatic acids, mol. wt>250

SOILS BRANCH DRILL HOLE LOG

Land Location NW Sec. 34 Tp. 38 R. 27 W. 4

Date July 10, 1985 Supervisor M. deBrentani

Project Red Deer (Sewerage)

Test Hole 313 to 317 inclusive.

Test Hole 313

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
0 - 2	fill, brown, granular, silty sand	d
2 - 3	sand and gravel	d
3 - 6	till, brown, sandy, pebbles, poor cuttings	s

installation: watertable well, 5 m deep, slotted 2 - 5 m below ground level, 2" PVC pipe

Test Hole #314

0 - 3	sand and gravel	d
3 - 10.5	shale, light grey, brittle, hard drilling	d

installation: none

Test Hole #315

0 - 1	garbage	vm
1 - 3.5	sand and gravel	s
3.5 - 6	shale, light grey, brittle, hard drilling	sm

installation: watertable well, 6 m deep, slotted 3 - 6 m b.g.l., 2" PVC pipe

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)

DEPTH (m)	TEXTURE AND LITHOLOGY	MOISTURE CONTENT*
Test Hole #316		
0 - 2.5	sand and gravel	d
2.5 - 3.5	sand, some gravel	m
3.5 - 6	shale, light grey, brittle, hard drilling	sm
installation:	watertable well, 6 m deep, slotted 3 - 6 m b.g.l., 2" PVC pipe	
Test Hole #315		
0 - 2.5	fill, brown, granular, silty clay	sm
2.5 - 7	garbage	s
7 - 8	shale, green grey, soft	vm
installation:	watertable well, 5 m deep, slotted 2 - 5 m b.g.l., 2" PVC pipe	

Moisture Content: d(dry); sm(slightly moist); m(moist); vm(very moist); s(saturated)